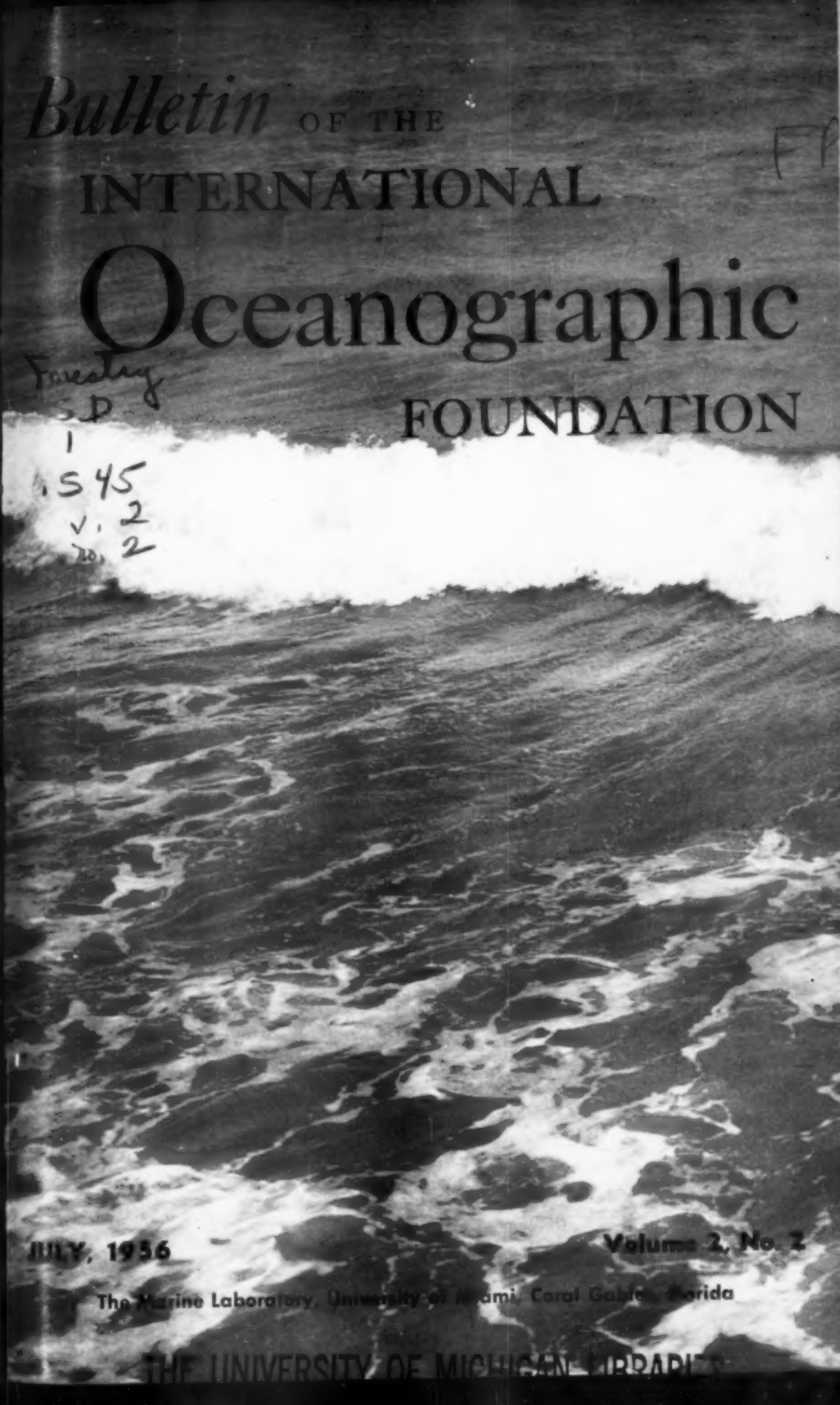

Bulletin OF THE INTERNATIONAL Oceanographic FOUNDATION

JULY, 1956

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The Marine Laboratory, University of Miami, Coral Gables, Florida

THIS MACHIAVELLIAN FACE *is not a winged sea monster in the legendary sense, but is an unusual view of an existing fish, the angel shark. If the illustration is turned upside down, it will show the fish lying on its back on a dark pavement. The winglike projections below the "face" are the fins. For further information* *see the story on page 109.*

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Editorial Office: The Marine Laboratory, University of Miami, Coral Gables, Fla.

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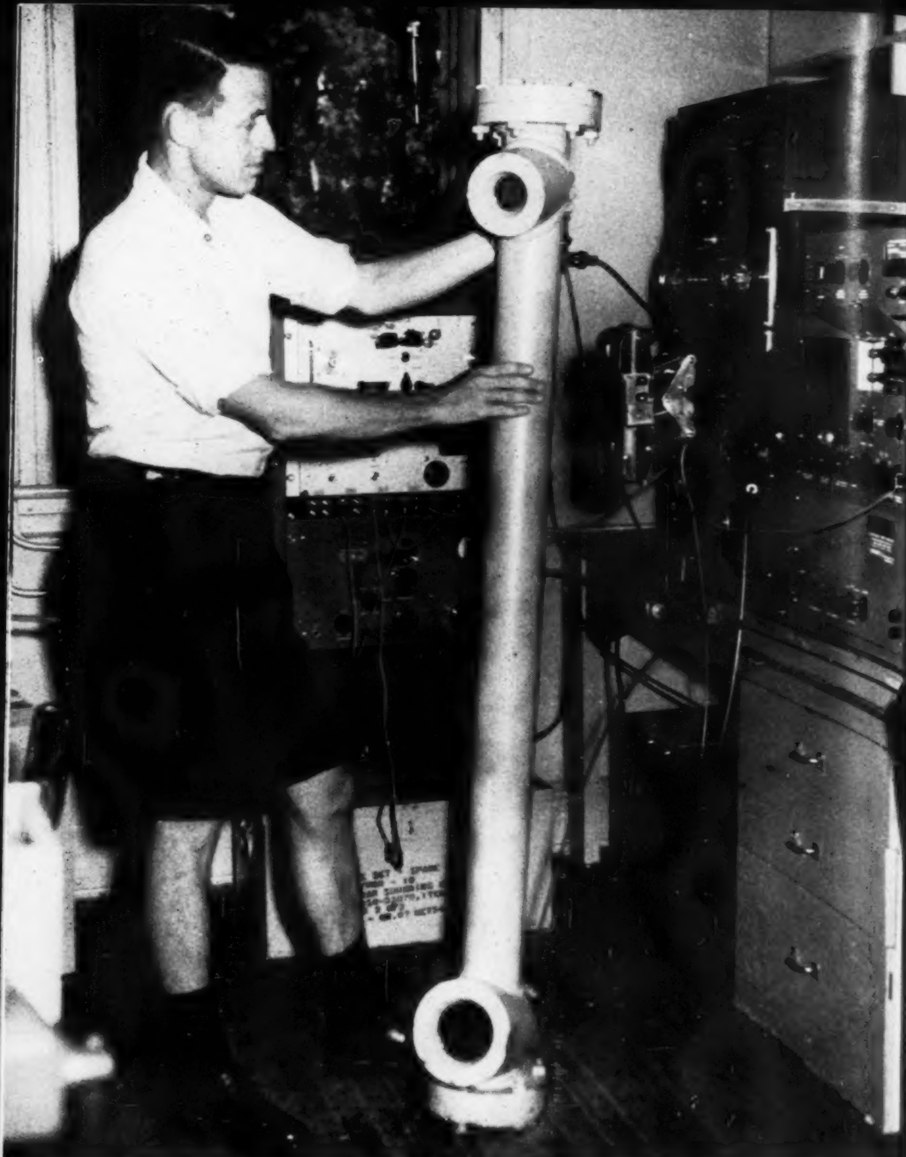


AMONG THE SCIENTIFIC ACTIVITIES *which are important to fishery development are instruments for detecting underwater sounds, as well as for using sound echoes to detect fishes. The bank of instruments on the right are used in analyzing underwater noises and echoes. The tubular instrument is the Edgerton camera, developed under the sponsorship of the National Geographic Society. Underwater photography is being increasingly used in fishery research.*

More To Fishing Than Fish

By F. G. Walton Smith

The rapid growth of the marine sciences, the increase in numbers of physicists, chemists, biologists and engineers who have turned their attention to the sea and the development of a number of new stations for marine research have awakened the public interest in this comparatively new frontier of investigation. Part of these efforts, perhaps too small a part, is directed to basic science, the exercise of scientific curiosity and imagination upon the unknown, purely for the pursuit of knowledge. This is a necessary preliminary to the task of putting science to work in ways more directly beneficial to mankind. For this reason it is a matter of concern that such fundamental research is so poorly supported financially. It is for this reason, too, that the useful applications lag behind in many ways when compared to the enormous technological progress which has taken place in man's activities on the land and even in the air.

Bounty of the Sea

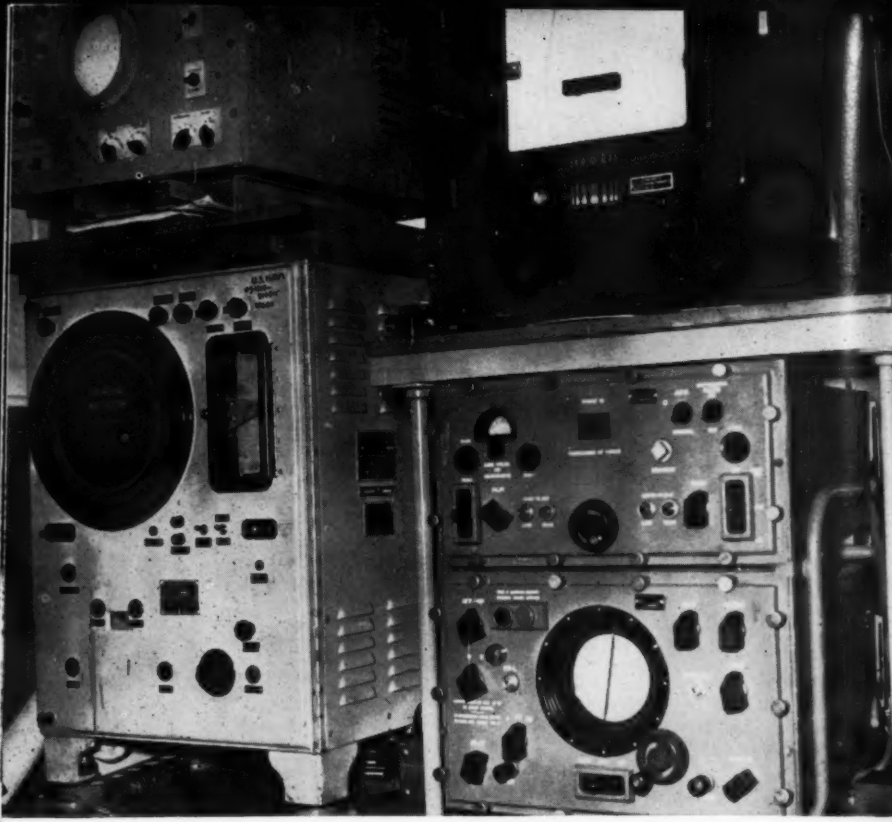
Just what are these applications of marine science which not only justify but urgently need the development of basic research? The field is broad, since it covers all possible activities of man related to the seas, their shallow margins, the waters below the surface, the floors of the oceans and even the atmosphere above them. It covers the whole great range of potential usefulness of the seas. Food, minerals and energy, the problems of navigation, the origin of storms and hurricanes and the transfer of heat from equatorial regions to warm the cold shores of lands nearer the poles, are all aspects of useful scientific interests. Some are more vital than others today, but the rapid growth in numbers of the human race and the increasing demands made upon natural resources makes it impossible to tell which of them may suddenly become critical. One of the scientific activities of growing importance already is that of fisheries research.

A Vegetarian Future

Seafood, in some countries, is a necessary part of food production. In others, such as the United States, a falling off of fish production could well be offset by agricultural activity at the present day. But even those optimistic persons who foresee a great increase of population with enough food from the land to support it are agreed that in order to do this we may have to cut down on our meat diet. It requires something like ten tons of vegetable matter to make one ton of beef on the hoof, so that the price of a greatly increased population may be enforced vegetarian existence—unless we are able to use the largely unexploited food production of the sea.

Need for Development

Whether a vital need or a luxury,



SOME OF THE *instruments used in research related to the fisheries. The echo sounder (lower left) is used both for navigation and for finding schools of fish. At top left is a specially designed fish finding device which operates off the main echo sounder. To the upper right is an instrument, the G.E.K., for measuring ocean currents.*

the fisheries of the world must adopt modern methods and improve their efficiency in order to develop or even to operate economically at their present level. The first step lies in exploration, the search for new grounds or extension of old ones. Since the distribution of fishes and their migrations are affected by the temperature and saltness of the water, by water currents and by the abundance of microscopic life in the water and by its chemical nature, or by the seafloor and the life upon it, the results of fundamental investigations in biological and physical oceanography should be of prime value in guiding exploration. As a matter of fact they have not been as valuable as might have been expected. The reason for this is that the complex relationships between these factors are still not fully understood and much of the required information is still scanty.

Fish Finding Devices

In exploration for new fisheries even more than in the routine fishery

operation itself, the use of fish finding devices is no longer the exception but the rule. Here we have the application of the understanding of sound transmission and reflection in sea water acquired by more fundamental studies. In some cases it may be possible to find fish by first finding the plankton or microscopic sea life. This was developed in the North Sea by Professor Hardy, whose plankton sampler and plankton recorder are applications of marine science to the practical purposes of the fisherman. Other possibilities for this deductive location of fishes may lie in store as basic science advances and applied science puts new knowledge into practice.

Antibiotic Ice

After the fish are caught a host of new problems arises. The fish must be kept fresh and be delivered to port in the best possible condition. The development of deep freezing, of special brine tanks and of antibiotic ice have contributed to this. Once landed, the fish must still be kept in fresh condition. Even though protected from bacterial decomposition, they lose flavor due to enzymatic oxidation processes—to the layman

FOR ITS FULLEST *development, a commercial fishery must bring its catch to market in top condition. Experiments on improved methods of refrigeration and handling include tests on the quality of the product. Taste panels are used in order to obtain objective opinions as to flavor and freshness. In the illustration samples of cooked shrimp, handled by various methods, are being compared.*

BIOCHEMICAL RESEARCH *develops new byproducts from fish. It is also used to study the processes which result in staleness and off flavor of refrigerated fish, or such undesirable effects as discoloration of shrimp.*

they lose flavor and become stale. The modern fisheries laboratory is engaged in all these phases of applied science plus the added study of the development of new products, such as fishsticks, breaded shrimp, new canning packs, and even in the problems of economics and marketing. Such laboratories will be found at Lowestoft in England and on the shores of the other North Sea countries. They are found at universities such as the University of Washington, Seattle, and the University of Miami, in Florida. Government organizations such as those of the U.S. Fish and Wildlife Service and the Australian Division of Fisheries support an elaborate organization of separate stations and in the United States the individual states have their own organizations, of which California has the most extensive.

Modern Instruments

Because of the extraordinarily wide range of scientific problems which are encountered in fisheries research, the station for seafishery investigations is likely today to include in its list of

personnel not only fishery biologists but electronics and acoustics designers and engineers whose work may include the development of underwater television for the observation of experimental nets in action, or of special instruments for attachment to midwater nets which continuously transmit back to the experimental fishing vessel the depth at which the net is working and the temperature of the water through which the net is passing. They may record the actual sounds made by fishes, both within and beyond the audible range, and subject them to acoustical analysis. Or investigations may be made of the potential use of electrified nets for attracting shrimps from obstructed seafloors to within the catching range of the net riding above the risk of damage by these obstructions.

Engineering Problems

The design of improved nets, hauling gear or winches calls for the services of fishery engineers. Even the fishing vessel comes in for its share of attention. (See *Are New Shrimp Boats Acomin'?,* by Edwin H. Mairs, Page 54, Volume 2, No. 1 of this Bulletin). Most fishing vessel designs have grown from a smaller model and, since the fisherman is conserv-

EXPERTS CONTINUALLY EXPERIMENT *with new methods of packaging or new types of products such as breaded shrimp or fishsticks in an effort to awaken the public interest to the high qualities of seafood. Samples are here shown being distributed in a large Miami food store.*

ative in his outlook, the larger vessels today are not always perfectly adapted to their changed conditions of operation nor are they always the most seaworthy for their job. The United Nations F.A.O. a few years ago recognized the importance of fishing boat design and held a world-wide conference on fishing boat design, divided for convenience into a meeting in Paris, France and another at Miami, Florida, in the United States. Problems considered included design of winches, main engines, cables and the ship itself. Plans for factory ships were engineered to provide for the entire processing of fish from catching to packaging as frozen fillets. Such questions are so important that, in the United States, the Ocean Resources Institute has been formed for the express study of engineering problems.

No less important, but older in practice, is the practical management of the fisheries, or conservation in its broader sense. Here a study of the fish populations, their natural growth and decline, breeding potentials and the effects of fishing upon them is a necessary preliminary to encouraging wise exploitation and setting up wise restrictions, often by international agreement. Even this cannot be divorced from engineering problems since the design of nets may be an important factor in preventing wasteful fishing.

Need for Basic Research

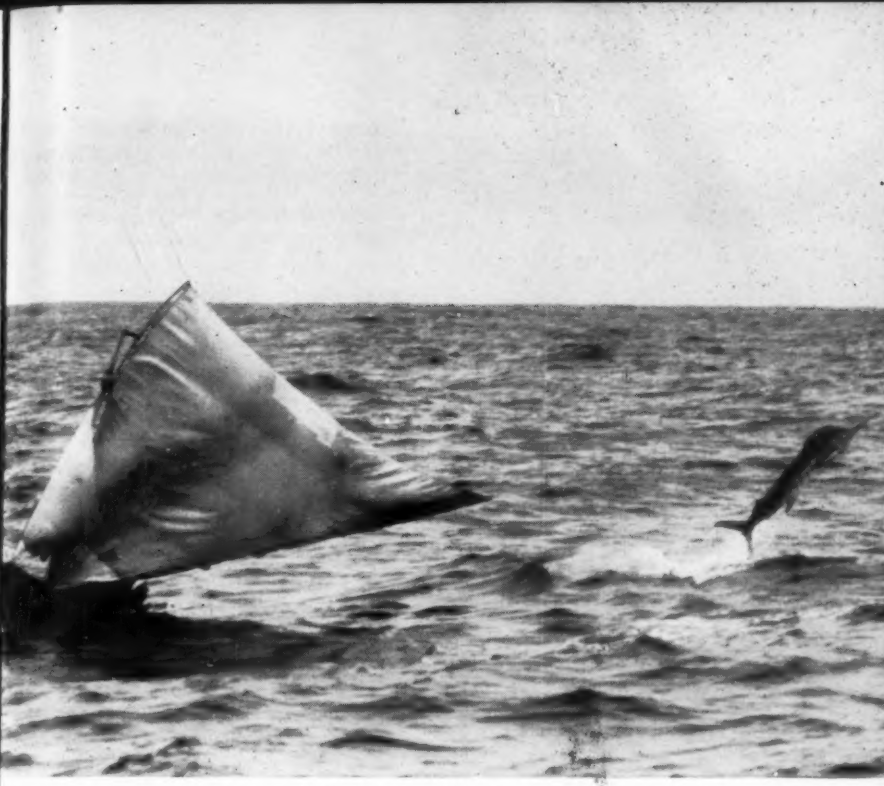
So far we have considered only the offshore fisheries, but much of what has been said applies equally well to the development and maintenance of inshore fisheries and even to shell-fisheries and oyster cultivation. These have their own special problems, however, and merit separate consideration. For the most part their development is limited though their maintenance is nonetheless important and improved methods are still needed in order that they may attain maximum economic efficiency. They have this in common with all fisheries, that the future depends upon the application of scientific knowledge to a practical purpose and this in turn depends upon basic researches which, because their immediate results are less obviously valuable, are apt to be neglected and in need of support.

FOR FURTHER READING:

The Inexhaustible Sea, by Hawthorne Daniel and Francis Minor. Dodd, Mead, 1954. An account of life in the sea including food fishes. Includes a chapter on fishing craft and factory ships. For the general reader.

The Sun, the Sea and Tomorrow, by F. G. Walton Smith and Henry Chapin. Chas. Scribners Sons, 1955. An examination and discussion of the sources of food, minerals and power from the sea. An evaluation of what is being done to increase the yield of the resources of the oceans. For the general reader.

Marine Products of Commerce, by Donald K. Tressler and J. McW. Lemon. Reinhold, 1951. A more technical handbook on the capture, handling and preservation of marine products.



THIS MIGHT BE *an illustration from "The Old Man and the Sea", but is really an indication of the amazing number of marlin found off the coast of Ecuador. Members of the Lou Marron University of Miami expedition have described the manner in which native fishermen, operating from frail dugout canoes such as this, as much as 30 miles from the coast are able to catch, single-handed and with only a handline, fish weighing as much as half a ton.*

Saltwater Gamefish

INFORMATION on big game fishes throughout the world continues to reach the Foundation from members of the Gamefish Research Committee. Among these are Mr. William Saltmarsh of Pretoria, who is in touch with saltwater fishing throughout South Africa as the honorary Publicity, Information and Records Officer of the South African Angler's Union. A second source of information from South Africa is Colonel John K. Howard, a member of the Board of Trustees of the Foundation who spent part of the winter of 1955 in South Africa and Mozambique

THE FIRST STRIPED MARLIN *ever to be properly identified in South African waters weighed 163 lbs. and was taken in Mossel Bay in February of this year. It was identified by Professor J. L. B. Smith.*

(Portugese East Africa) in the study of billfishes for The Marine Laboratory of the University of Miami. Colonel Howard received valuable assistance from Mr. Saltmarsh while working South Africa.

Conditions in South Africa

According to Mr. Saltmarsh, there are no deep sea angling clubs and no charter boats suitable for big game fishing in South Africa so that this type of angling is restricted to the few individuals who own their own boats. Furthermore, because of the exposed nature of the coast, angling must be carried out from the main harbors of Durban, East London, Port Elizabeth, Mossel Bay and Cape Town. There are plans to improve this. It is hoped to form a Deep Sea Sport Angling Club in each province in order to develop the sport and in order to warrant recognition and provision of harbor amenities by the Union Government.

In spite of the lack of development, some good catches have been made. For instance, among the recorded catches from shore fishing, mainly by surfcasting, are a 469 pound brindle seabass, one of the jewfish, sometimes called garrupa; a 122 pound kingfish related to the jacks; a 162 pound salmon, which not a true salmon but a member of the croaker family. This family, in South Africa, is of especial scientific interest because of the high

Vitamin A content of the livers, many times that of codfish; a 628 pound black shark; a 1660 pound blue pointer man-eating shark; a 625 pound grey shark; a 649 pound ragged tooth shark; and a 1034 pound tiger shark. Altogether shorefishing has been amazingly productive.

Marlin on Artificial Lures

Mr. Saltmarsh also includes in his report the log of a fishing trip to Bazaruto Island off the coast of Portuguese East Africa. On a ten day trip the party caught four marlin and lost one. The weights were 320 pounds, 160 pounds, 25 pounds, and 18 pounds. This catch of two very small fish is most interesting and may lead to the identification of nearby spawning or nursery grounds. Anglers will be interested to note that these fish were all caught on artifical lures. The 320 pounder was taken by a Jensen Wizard Chrome Plated No. 4 spoon, the 160 pounder on a red, blue and yellow feather, the 25 pounder on a Creek Chub plug and the smallest on a Creek Chub pike plug with 3 triple hooks. The whole question of bait preference is one which requires scientific investigation and may lead to important information as to the sensory behaviour of these fishes.

Colonel Howard, in addition to capturing billfish himself, has made arrangements with sport fishermen in this area to make measurements and

A 435-POUND SPECIMEN *taken in Mossell Bay, April 1956 and identified as a Black Marlin. One of the most obvious of the distinguishing characters of this species is believed to be the rigid pectoral fin.*

A 375-POUND *"Silver" Marlin, caught by ex-governor Ewing of Pago Pago, American Samoa, while trolling a few miles off Suva Harbor, Fiji Islands. Ewing is at the right in the above picture, with E. H. Terry of Suva, whose son R. E. Terry is a corresponding member of the Gamefish Research Committee of the Foundation. The identity of the so-called Silver Marlin is still in doubt but it may possibly be the same species as the Atlantic Blue Marlin.*

take photographs of their marlin and sailfish captures in order to augment the work which is sponsored by the International Oceanographic Foundation and Mr. Charles F. Johnson and carried out by The Marine Laboratory of the University of Miami.

Gamefish in Fiji

Mr. Roydon E. Terry reports that yellowfin tuna are very plentiful in the Fiji area. Large schools of these fish enter the waters and are practically everywhere in this island group. They are first sighted about the beginning of March of each year, but sometimes are seen a month earlier. About May, they disappear but leave a few which pair off and go down deep.

The large marlin sometimes caught in the Fiji Islands are known there as silver marlin. While the picture shown herewith is of a 375 pounder, others have been hooked and lost with estimates of weight as much as 600 to 700 pounds. Inasmuch as scientific identification of marlin in the Fiji Islands has never been made, it is quite possible that the ones referred to by Mr. Terry are not the silver marlin of other parts.

Plenty of Sailfish

Fishing in the islands when Mr. Terry wrote the report in late March were Mr. and Mrs. Frank Hayford of Midland, Texas. They had caught a 156 pound sailfish, hooked and fought by Mrs. Hayford, and a 144 pound Allison tuna that Mr. Hayford had fought and boated. "There were four or five sailfish all making a grab at the lure, a Hawaiian plastic plug, when Mrs. Hayford caught hers," Mr. Terry comments. "Unfortunately for me, I had to return to work and couldn't finish the trip with them. However, my Dad is guiding for them, and even though the weather is terrible just now, there should be a good story when they return."

Many Countries Represented

With the 13th Annual International Tuna Cup Match scheduled for September 12, 13, and 14, the informa-

A TYPICAL *Wedgeport launch, used by anglers for catching the giant bluefin tuna. Miguel Barrenechea of Mexico rides a wave during the 12th International Tuna Cup Match in 1955.*

tion on these widely-known fishing competitions furnished by Israel Pothier, secretary of the Wedgeport (Nova Scotia) Tuna Guides Association and member of the Gamefish Research Committee of the International Oceanographic Foundation is timely.

It is estimated by Mr. Pothier that 10 teams will compete in the coming match. Compare this with the two teams, British and United States, that competed in the inaugural match in 1937, in order to see how these competitions have grown in popularity. Last year, for instance, seven teams comprising 42 anglers from 11 countries on three continents and three islands were entered in the match. The teams represented Argentina, British Commonwealth, Chile, Cuba, Mexico, Venezuela and the United States. In the series of annual matches, the 1939 match was concelled due to the outbreak of World War II, but were resumed in 1947. Teams from Cuba have won the Alton B. Sharp Trophy, top prize, three times. The British, Mexican and United States have won it twice each. The only other team to have its name inscribed on the gleaming surface is Chile.

Wedgeport's fame as a bluefin tuna headquarters began in 1935 when Michael Lerner, internationally known sportsman, stopped there for gasoline while motoring to Yarmouth to board the ship for Boston. He was impressed by the conversation he heard about the great size and the abundance of the tuna taken commercially near Wedgeport, so he can-

IT TAKES REAL EFFORT *to boat large tuna such as the 656-pounder caught by Mexican angler Guerra in the 12th International Tournament at Wedgeport, Nova Scotia.*

celled his steamship reservations and made plans to fish the next day from an old lobster boat. He fished eight days and boated 21 tuna.

Lerner and his friend, S. Kip Farrington, Jr., had been fishing together in Nova Scotia. Mr. Farrington arrived in Wedgeport just behind Mr. Lerner, and the two concluded that Soldier's Rip was one of the finest fishing holes they'd encountered in their worldwide quest for big gamefish. The Rip, incidentally, is a six knot tidal stream about a mile wide near Bald Tusket Island, about 10 miles south of Wedgeport. Tuna come to the Rip to feed on the schools of herring and mackerel which congregate there.

Opportunity for Research

Naturally, where so many bluefin tuna are caught each year, a wonderful opportunity is available for scientific study of these giants of the sea. Thus, over the years since sports fishing has been popularized at Wedgeport, scientists from the American Museum of Natural History, The Marine Laboratory of the University of Miami, the Bingham Laboratory of Yale University and the Woods Hole Oceanographic Institution have carried on their research there, seeking to learn the life history, migrations and feeding habits of bluefin tuna in order to add to the world's knowledge of this important food and sports fish.

Bluefin tuna usually appear off the south coast of Nova Scotia late in June, following their run from the Caribbean area and up the Gulf Stream. By October they have moved on, but where they go and what route they take on their southern migration is still a subject for research. They are taken at many places along the Nova Scotian coast—off Cape Breton, Shelburne, Jordan Bay, Liverpool and Lunenburg—but the fishing grounds off Wedgeport are the most famous.

Last year was a very poor one so far as numbers of tuna caught was concerned. In 1954, 288 of the big fish were taken, and the average summer catch is 562 tuna. After 1949, when a record 1774 bluefins were caught, the catch declined. However, the total 1954 catch was a gain of 120 per cent over 1953, leading to a belief that a rising cycle had begun.

What the catch will be this year, and whether anglers can look forward to the same good fishing as formerly, is a question that cannot be answered until the season has been underway for some time. Eventually, with more scientific study and investigation, it may be possible accurately to foretell just how large and how responsive the annual tuna runs will be. The acquisition of such knowledge presents a challenge to scientists and likewise to commercial and sports fishing interest. Plans are already afoot for an investigation of the relation between prevalence of giant tuna and conditions in the herring fishery. Possibly, fluctuations in water temperature affect the tuna movements either directly or through the movements of the herring schools on which they feed. This year an experiment will also be conducted to determine whether bluefins can be attracted to the Rip by large scale dumping of herring chum on the outgoing tide.

Striped Marlin at Mazatlan

One of the most prolific centers for catching billfishes is Mazatlan, at the entrance to the Gulf of California. Foundation members Pedro Pinzón and his wife, Jane, have been active in promoting both angling and the scientific study of big gamefish here. During the course of a year it is reported that over 5,000 sailfish and striped marlin with an occasional black marlin are caught.

Breeding conditions, measurements, stomach contents, and other data for Mazatlan marlin and sailfish have been obtained by scientists of The Marine Laboratory of the University of Miami as part of the Charles F. Johnson Gamefish Investigation. During the International Light Tackle Tournament held there last April assistance was given to Laboratory scientists by Dr. Roy Dean of Mexico City, who is a member of the Foundation's Gamefish Research Committee. Dr. Dean is known as the father of light tackle angling in Mexico and has provided much valuable information to those engaged in scientific investigation.

Japanese Longline Gear

One of the handicaps met with in studying the migrations of big gamefish has been the relative paucity of information that can be obtained by exploratory fishing with rod and line. Even when the fish are present, their variable reaction to different kinds of baits and lures and the fact that at certain times or seasons they may be running deep below the surface are factors that conspire to hide their

THE U.S. TEAM *receives the Sharp trophy, for capturing the 12th International Tuna Cup Match, Wedgeport, Nova Scotia, September 7-9, 1955. Left to right: Maurice Meyer, Long Branch, N.J.; A. M. Whisnant, Jr., NYC, N.Y.; Don A. Allison, Beverly Hills, Calif.; Alton B. Sharp, Boston, Mass., donor of trophy; Joe D. Peeler, (captain) Los Angeles, Calif.; Neumann Harris, Broken Bow, Neb.; William K. Carpenter, Wilmington, Del.; and William Negley, San Antonio, Tex.*

THE JAPANESE LONGLINE TYPE *of fishing gear was developed for commercial fisheries but is now being adapted for the study of the larger game fishes. The illustration shows the type of gear recently installed on GERDA for hauling in the longline. The line, with its hooked gangions or leaders, is led between the rollers on the rail and passes over the motor driven pulleys which haul the line and coil it in the basket or tub behind it.*

presence or to render valueless any information as to relative abundance.

For this reason a modified commercial longline gear has been used experimentally aboard GERDA, research vessel of the Miami research station, for the study of billfish distribution. This type of gear is made up of units, each of which is called a basket. The basket consists of 138 fathoms of hard laid 132-thread nylon line, forming the mainline, with ten gangions spaced at equal intervals along it. The gangions are attached to the mainline by swivelled wire tees and consist of 3 fathoms of soft laid 11/64 nylon with 1 fathom of 3/32 stainless steel leader, carrying a 9/0 Mustad hook of the Japanese pattern with natural frozen bait. Each basket has a buoy rope and buoy so that the entire mainline may be set at any predetermined depth.

This type of gear has been used successfully by the Japanese tuna fish-

ermen and has also been used to good purpose by the U. S. Fish and Wildlife Service vessel OREGON for exploratory fishing in the Gulf of Mexico and part of the Caribbean. For the initial tryout of this gear in the Bahamas aboard GERDA only 10 baskets were used with a total of 100 hooks, but in normal operation a much longer line would be used. It is believed that with gear of this type such problems as the migrations of the bluefin tuna, still incompletely known, could be quickly solved.

The Rigid Pectoral Fin

The well known taxidermist Al Pflueger, who has contributed much to the natural history of marine fishes, was one of the first to point out two important characteristics which may be used for the rapid identification of black marlin and the blue marlin. While not fully accepted, there is considerable agreement that the black marlin differs from other species in the possession of a so-called rigid pectoral fin, which cannot, as in other marlins, be bent back against the body. It is understood that Dr. James Morrow of Yale University may shortly publish the results of investigations upon the bone structure of the shoulder girdles of marlins, which may throw new light on the nature of the rigid fin.

No Lateral Line in Blue Marlins

The second characteristic involves the lateral line, the chain of sense organs which show as a more or less well defined line running along both sides of most fishes. In the case of the blue marlin alone the line cannot be distinguished, but, instead, there appears a faint network of lines about the size of coarse chicken wire. This is especially noticeable when the skin is dried and the scales have been removed. Specimens of this are being preserved at Miami by Donald de Sylva and Dr. Charles E. Lane for microscopic examination in order to determine the manner in which the lateral line has become modified.

New Area for Broadbill Swordfish

A new broadbill swordfishing area has been located off the coast of Chile, it is reported by Foundation Fellow John Manning, who, with Mrs. Manning, is working in that locality as associate with the Marine Laboratory of the University of Miami.

Following a study made last year, Manning predicted that there should be a fairly solid concentration of swordfish off Valparaiso in an average season. Proceeding according to plans instituted by Manning, a native commercial harpooner from Iquique, Nelson Arena, visited the area and harpooned the first swordfish to be taken in the locality.

"In 27 operating days we were able to stay at sea, we sighted 22 swordfish and boated 11," Manning reports. Mrs. Manning caught one of the big gamesters on rod and reel, while the other 10 were harpooned.

The swordfish varied in weight from 200 to 1038 pounds, with one specimen in nearly every hundred-pound class, which gives scientists at the Marine Laboratory considerable to work on in relation to the life history of these interesting commercial and game fish.

THE **FAIRTRY** IS A MODERN *factory fishing vessel of 2605 tons gross. She has stern operating net gear, mechanical filleting machines, and a fish meal plant. Experiments of this kind are expensive and great credit is due the Charles Salveson Company for their initiative and enterprise in taking the lead.*

Floating Fish Factories

By ROBERT W. ELLIS

The Marine Laboratory, University of Miami

THE housewife likes the fish she buys to be as fresh as possible. This is not always too easy and many ideas have been tried in order to improve the marketing of fish in prime condition. A modern method of obtaining quality in fish is to process it soon after catching. This technique demands that the fish plant go to sea. As it is almost impossible to transfer large catches at sea from a catching boat to the processing boat, it is necessary that the processing boat catch her own fish. Shipbuilders and fishing vessel owners have been interested in this possibility for some time and some boats have been built to serve this function. The designing of such a vessel is a complex matter and its operation calls for special skills of the

captain and crew. Due to the high cost of operating such a vessel it can only be used on highly productive fishing grounds with specially adapted gear.

THE LARGE SIZE *of factory ships and the height of the rail above water makes it impossible to take in the trawl net at the waist of the ship. A special ramp is therefore provided at the stern as shown in the illustration of FAIRFREE, first of the experimental factory ships built by the Charles Salveson Company, well known Anarctic whaling operators.*

Some of the Problems

The plant vessel must be larger than a normal fishing boat in order to provide extra space for the special personnel and equipment. The use of a larger vessel complicates the operation of the fishing gear. Such a vessel would clearly be expensive to build and operate and thus beyond the means of a small fishing vessel owner. Finally, few of the fishing grounds of the world are consistently productive enough to enable such a vessel to operate economically.

Fishing Boat Congress

The complex and sometimes conflicting demands made on designers by the factory ship and the division of opinion on the economic feasibility of the idea led to a special study of these questions by the United Nations Food & Agricultural Organization in 1953. A Fishing Boat Congress, drawing naval architects, fishery en-

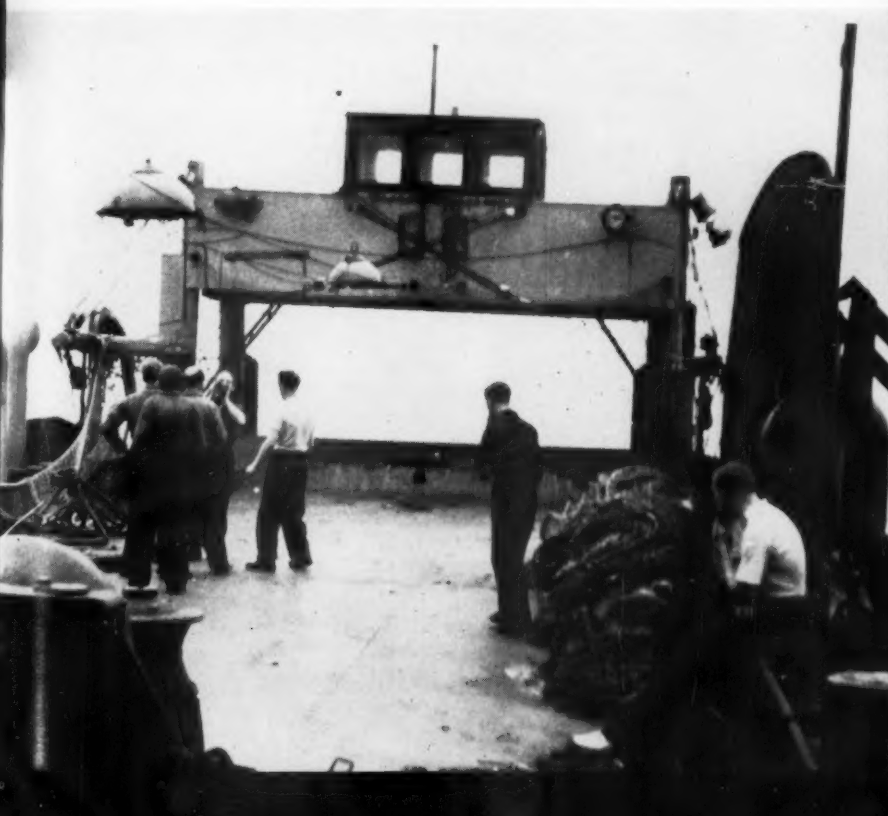
gineers, technologists and fishery biologists from the major countries of the world, was organized. Because of its very wide interest this congress was held not only in Paris, France, but also in Miami, Florida, in cooperation with the Gulf and Caribbean Fisheries Institute. The Fisheries Institute is an annual meeting organized by the Marine Laboratory of the University of Miami.

The Fishing Boat Congress provided an assembly of papers and discussions on the many experimental types of vessels, such as the Pacific Coast processing ships, including the *Pacific Explorer* and the *Deep Sea,* a freezer trawler for king crab. Some of the most advanced of the Atlantic vessels mentioned were the British freezer and processing trawlers, *Fairfree* and *Fairtry*.

Can these Problems be solved?

These two vessels are operated by the Scottish company of Charles Salveson, famous operators of Antarctic whaling fleets, who first experimented with the *Fairfree*. This vessel was truly revolutionary in many of her features. On first seeing her, many

THE USE OF *a stern ramp for hauling the net, together with her large size and other features, gives the factory vessel an entirely different appearance from the ordinary fishing boat. The illustration shows the appearance looking from amidships to the after end of the ship, with the special control bridge for use in fishing operations.*



FACTORY SHIPS *are able to carry out the entire work of processing and packaging fish at sea. The illustration shows part of the factory deck.*

conservative Scottish fishermen shook their heads and said that the *Fairfree* would never catch fish or, if she did, the vessel could never be operated at a profit. After the first year of operation it looked as though the pessimists were right. Despite the tremendous efforts of the Charles Salveson Company, Captain Jimmy White and his crew, the *Fairfree* seemed incapable of fulfilling her required purposes. Gradually the difficulties were solved, a few good trips were made and top quality fish were landed in Scotland.

Special Features of the FAIRFREE

Freezing and processing equipment were required so the boat had to be larger than a conventional trawler. The 230 ft. length made the vessel longer than any other trawler at the time. The height of the rail above the water made standard fishing methods impossible. This problem was solved by operating a trawl over a ramp at the stern. Special doors were fitted on the deck so that when the fish were brought inboard, they were dropped to a plant deck below and all further operations were done under cover. Immediately after catching, all fish were cleaned, the larger ones hand filleted and the whole catch quick frozen, wrapped, packed and stored in refrigerated holds. Each operation

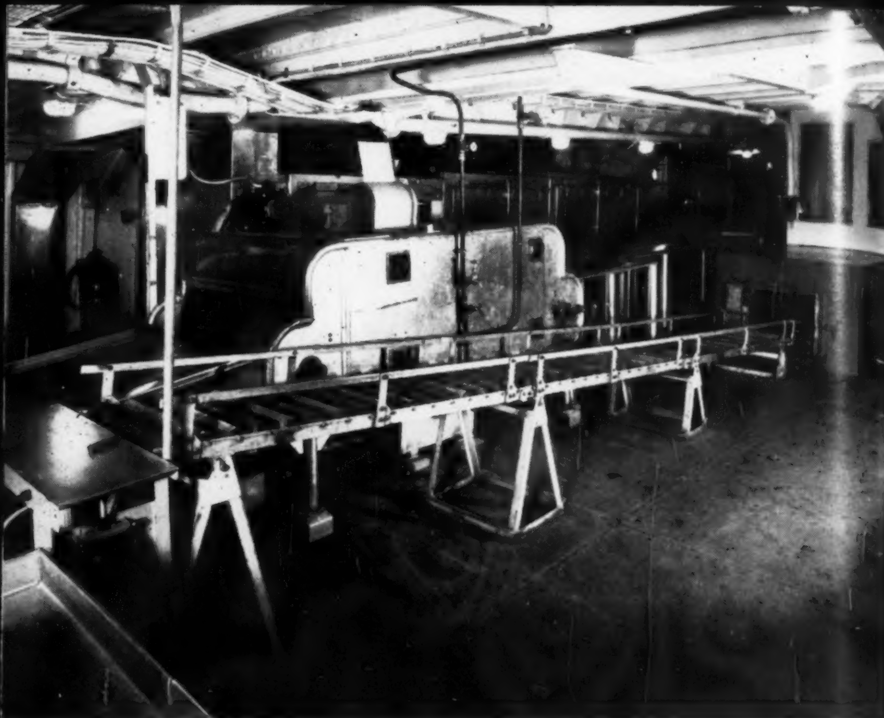
required the devising of special techniques and the designing of special equipment. The catches of fish in Scottish waters proved to be inadequate and trips were made to the Grand Banks of Newfoundland where good catches were obtained.

Fishermen all over the world watched the operation of the *Fairfree* with interest. She seemed to incorporate many ideas that fishermen had talked about but scarcely believed possible at that time. Of course, as is true with any new idea, snags cropped up continually and experimentation was expensive. Surely the people who had faith in this idea and patientiy tried to overcome the many problems deserve great credit. Close cooperation was maintained with fishery biologists and technologists throughout the experimentation period.

Success Achieved

The many years of experimentation were rewarded when the faithful *Fairfree* finally was tied up and a new vessel, the *Fairtry*, was sent across the Atlantic on her maiden voyage. The *Fairtry* incorporates all the best features of her predecessor and many new ones. She is larger, 280 ft. in length, and includes a variety of labor saving devices and electronic navigational equipment. The method

THE FILLETS ARE *wrapped and then packaged in cartons, so that, when landed, the fish are ready for delivery to the consumer or to cold storage.*



AFTER CLEANING, *filleting, packaging and weighing the fish are carried to the glazing machine and then on a conveyer to the refrigerated hold. The entire process takes place at sea.*

of fishing is basically the same but mechanical filleting machines and a fish meal plant allow for better and fuller utilization of the catch. The quality of the product is unimpaired and the working and living conditions for the crew are superior to those of any other fishing vessel afloat.

It is one of the functions of oceanographers to study the wise management of fish resources. Another important function should be to encourage the best possible use of these resources. The *Fairtry* seems to represent one of the most efficient instruments of fish utilization at the present. She has set a high standard and already some of the fishing nations of the world are experimenting along the same lines.

Rivers in the Sea

THE PASSENGER ABOARD SHIP, out of sight of land, sees only the motion of his vessel through the water. There is nothing visible about the sea surface to show whether the water itself is moving, either as a favorable current, helping the ship's progress, or, as an adverse current, retarding it. Yet currents do exist in the open sea, of such power as to make a substantial difference to the daily distance made good by the ship and so be important to the mariner as a factor in fuel economy as well as in his navigational estimates. It is important, then, to measure the speed of these rivers in the sea and to know how they vary from season to season, day to day, and even hour to hour. The ways of doing this are surprisingly varied and involve some of the most ingenious ideas and devices in the science of oceanography.

Importance of Currents

There are other ways in which ocean currents are important. Near the equator the surface of the sea gains heat from the sun, whereas there is a heat loss at the poles. The action of such currents as the Gulf Stream, carrying warm water poleward, has a profound effect upon climate and weather. The distribution of fishes is dependent upon sea water temperature, and is thus both directly and indirectly related to ocean currents. Currents not only carry food in the form of microscopic sealife or plankton but also help to distribute the fertilizer materials upon which they grow. There are numerous other problems both of scientific and practical importance which involve a knowledge of the pattern of water movement in the sea and today there is the most recent one of disposing of radioactive wastes at the bottom of ocean deeps. This requires a knowledge of how long it would take for deep bottom water at any given place to reach the surface. If the time is great enough, much of the radioactivity might be lost, otherwise it would become a hazard.

Giant Eddies

The major currents of the world, with some exceptions, run as part of a continuous circulation, completing a clockwise circuit in the northern oceans and a counterclockwise one in the southern oceans. In general, the current flowing towards the pole on the western side of the ocean tends to be comparatively narrow and fast, whereas the corresponding current on the east, flowing towards the equator, tends to be wide and slow. Thus the Gulf Stream, a flow of between twenty-five and fifty million tons of water per second, is concentrated into a fairly narrow stream in its most westerly part, and has a maximum velocity of over six knots at times. Having crossed the Atlantic Ocean, the stream veers south again, off the coast of Africa, to complete the cir-

OCEAN CURRENTS *are important for many reasons. One of these is the distribution of temperature, salinity and the fertilizer salts dissolved in seawater which play a large part in determining the fertility of any part of the ocean. The illustration shows large flocks of birds feeding upon a great concentration of fish in the sea off Iquique, Chile, where the Peru current and vertical movements of water account in part for unusual fertility of the sea. (See article on Peru Current in Volume 1, No. 2 of this Bulletin.)*

cuit. Here, as the Canaries Current, its flow is very slow and is spread over a wide area. The counterpart of the Gulf Stream in the North Pacific is the Japanese Current, the Kuroshio, and in the Indian Ocean there is the strong Agulhas stream flowing south, off the coast of east Africa.

There are, of course, many other currents besides those which form the major circulations of each ocean. Some are tidal, others due to seasonal winds, to unequal heating of the water, or indirectly caused by winds which pile the water up against the coast, thereby bringing about a longshore current parallel to the coastline. And here it may be said that, as a rule, the currents caused by winds do not flow in the direction of the wind, but at an angle to it, with a right-hand twist in the northern hemis-

phere, left-hand in the southern hemisphere. Thus the trade wind of the southern North Atlantic blows from the northeast in a southwesterly direction towards the equator but the north equatorial current which it drives across the Atlantic moves to the right of the wind, in a westerly direction towards the Windward Islands.

Although for the most part, the ocean circulations of the two hemispheres do not directly intermingle there is a current which branches off from the South Equatorial Current, flows across the equator and joins the westerly movement into the Caribbean. This transports something like six million tons of water a second across the equator. There is no compensating surface current in the opposite direction, and the North Atlantic and Polar Sea have no other outlet. Obviously there must be an accounting for this net gain of surface water by the North Atlantic, and equally obviously there must be a compensating return movement somewhere. Since it does not take place at the surface there is, as might be expected, a flow of water deep below the surface, to the south. A number of compensating flows of deep water are found in all of the major oceans and they, in turn, are linked to vertical movements, the transfer of water back and forth between the surface and the deeper layers.

Sinking Water

The net gain of surface water to the North Atlantic is balanced by water which leaves the surface and sinks below in areas between Greenland and Iceland, in the Labrador Sea, and to the west of where the Mediterranean communicates with the Atlantic. Each of these three downward movements removes from the surface about one third of what the Southern Equatorial Current brings to the North Atlantic. There are reasons for these vertical movements, based upon unequal heating and cooling of sea water and upon evaporation and rainfall. The hotter seawater becomes, the lighter it is so that it tends to rise to the surface. The cooling of seawater has the reverse effect and gives it a tendency to sink. Evaporation of seawater at the surface, due to winds and the heat of the sun, makes it saltier and heavier. The addition of freshwater by heavy rains has the effect of reducing the salinity and so causing surface water to become lighter.

Six Million Tons Per Second

The surface of the Mediterranean Sea loses more fresh water by evaporation than it gains from river discharge and rainfall and therefore becomes heavier than the water in the adjacent Atlantic. The result is that in the Straits of Gibraltar there is a two-knot inflow of lighter surface water from the Atlantic to the Mediterranean and this is compensated for by a deep sub-surface flow of the heavier Mediterranean water into the Atlantic. This continues to sink and joins the deep south-flowing stream on its way to cross the equator. A similar amount of surface water joins the deep southward flow by sinking


SURFACE CURRENTS OF THE NORTH ATLANTIC
EUROPE
AFRICA
NORTH AMERICA
SOUTH AMERICA
North Atlantic Current
E. Greenland Current
W. Greenland Current
Labrador Current
Gulf Stream
Sargasso Sea
Antilles Current
Caribbean Current
North Equatorial Current
Canaries Current
Guinea Current
South Equatorial Current

off Greenland and in the Labrador Sea at places where the cold Arctic waters, meeting warmer but saltier Atlantic waters, especially in winter, cool the latter by mixing until the surface waters become heavier than those below. The North Atlantic loses in this way a total of six million tons of surface water a second, but this amount returns to the surface in the South Atlantic, due to other forces, where it exactly replaces the six million tons of water which originally crossed the equator to enter the North Atlantic circulation.

Sources of Fertilizer

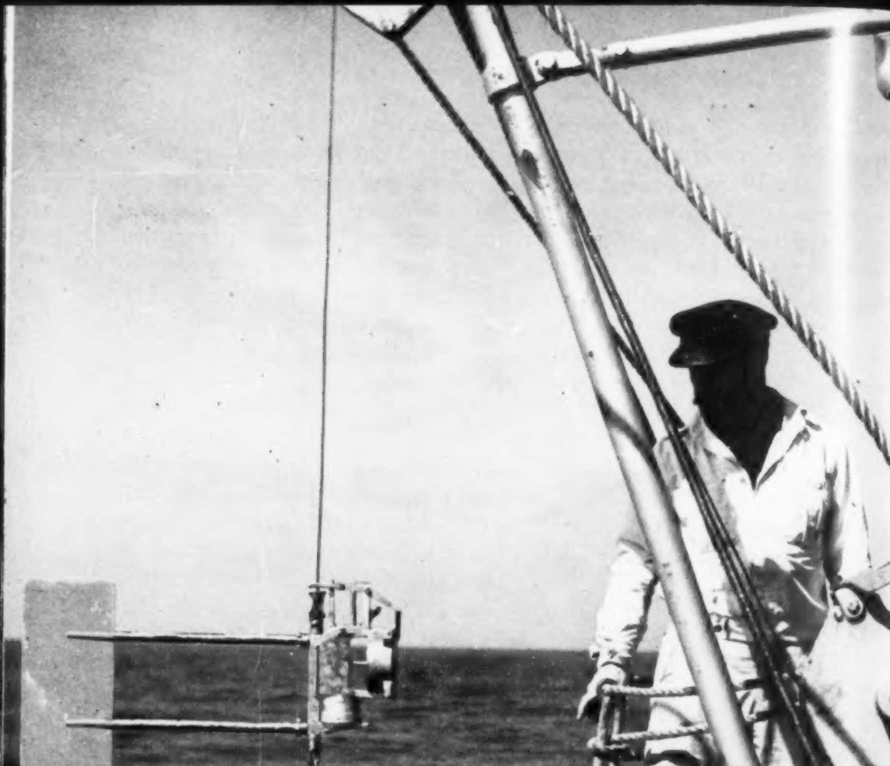
There is another type of vertical movement in the sea. When winds or other causes bring about a divergence of currents, water will well up from below to fill the void. Similarly, when currents meet or converge, there is a net displacement of water in a downward direction. Winds blowing away from a coast may have most important effects since the water displaced offshore must be replaced from below. The lower layers of water are often better supplied with natural fertilizer than those at the surface so that upwellings of water are apt to be more productive of sealife, including commercial fishes. The west coast of Africa is a good example of such a situation. The reverse case, when water is piled up along the shore, may result in a sinking of surface water which is replaced by less fertile surface water from offshore.

Measuring Currents

How is it possible to measure the rate of these various currents and to estimate the volume of water transported? There is a wide variety of methods available to oceanographers, some simple and some more complicated, but the simplest are those that are based upon the measurement of a drifting object. For instance, a line might be let down to the bottom with a weight for anchor and the ship allowed to drift, without power or sail. The rate at which the line is dragged out would provide an approximate measure of the ship's movement due to the current. When Columbus, half way across the Atlantic on his first voyage, tried to sound for bottom he failed to find it but the angle at which his leadline ran out from the becalmed ship gave clear indication that the ship was moving westward with the surface water layer while the weighted end of the line was in a deeper, relatively motionless layer. Today a ship may be moored to an ice flow and the current speed measured in a similar way by dropping a weighted line to the bottom and measuring the speed at which it has to be run out as the ship moves with the ice and current.

Currents from Ship's Logs

A great deal of information about currents has been obtained from the navigational records of ships, filed with the U. S. Navy Hydrographic Office. From this information the monthly averages of currents are charted. Using the known speed of the ship through the water a navigator is able to calculate what his position should be at the end of any given period of time, assuming that no currents are diverting the ship. At the



CURRENTS ARE MEASURED *directly by means of specially designed meters, similar in principle to wind recorders which are lowered on cables to the required depth. The fins ensure that the propeller which is turned by the current always faces towards it.*

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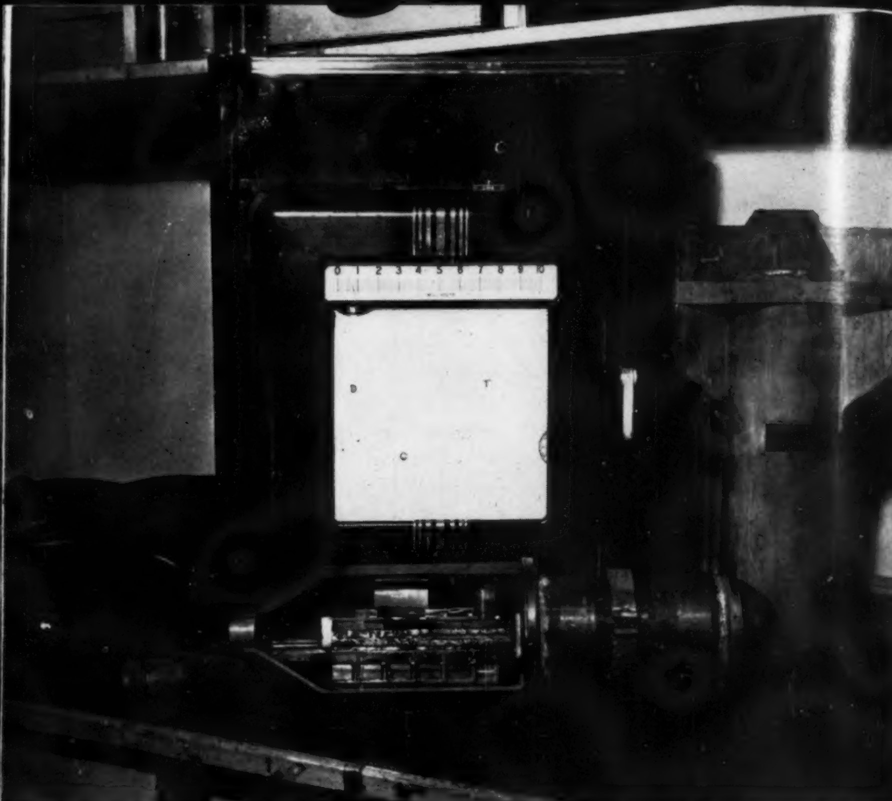
end of this time he finds his actual position or fix by taking bearings of a stationary light or by observations of heavenly bodies. The difference between the predicted position and the actual position gives the direction and speed of the current. Today, there are more and more reliable methods of fixing a ship's position, even with an overcast sky, due to the invention of Loran, radar, and radio direction finding. Even so, this method will only give the average current speed over a more or less extended distance and gives no information about the actual speed of current at any one point or about its variations.

Measuring the Ship's Speed

The speed of a ship is measured in a number of ways. The patent log, a propeller towed behind the vessel, clear of its wake, is attached by a cord to an instrument which records on dials the distance traversed. Another device, the pitot log, measures the pressure differences in tubes projecting from the ship's hull, and records this as speed, much as the airspeed indicator of a plane. The Kenyon log measures speed by the deflection of a blade projecting from the hull into the water. And the speed of revolution of the ship's engines and propellers may be used to judge her speed through the water when properly calibrated for various conditions. Most of these methods are designed for measuring the comparatively high speeds of ships through the water and are not accurate when used to measure the slower drift of ocean currents past the hull of an anchored vessel. Special instruments have therefore been designed for using from anchored vessels in order to measure currents, both at the surface and at various depths below. Lightships thus become of especial value to the oceanographer interested in currents at sea.

Flow Meters

Flow meters used from stationary vessels or buoys are frequently driven by means of a propeller or by a set of cups similar to those of a wind-gauge. These are set in motion by the water passing by. Their speed of rotation is proportional to the current, and they are so arranged as to register the number of revolutions on a dial. The Ekman type of meter, which has been used most frequently, also has an ingenious arrangement for showing the changing direction of the current. The propeller is geared so as to rotate a horizontal disc containing a single hole of the exact size to allow a small shot to pass through, from a shot reservoir above it. Every thirty-three revolutions of the propeller the hole arrives in position and the shot drops through the disc. Beneath the hole in the disc is a pivoted magnet carrying a channel along which the shot rolls. Beneath the magnet is a box with 36 radially arranged compartments, each corresponding to a 10 degree sector of the compass. The whole instrument is suspended so that vertical fins will keep it aligned with the direction of the current. Thus, each time a shot drops, the compartment to which the magnet directs it indicates the direction of the current.



THE C.T.D. IS AN INSTRUMENT *which measures temperature and electrical conductivity of sea water and the depth in which the instrument is working. The pressure, resistance and temperature elements at the bottom of the illustration are enclosed in the short torpedo like housing at the right and towed at varying depths behind the vessel. An electric cable connects the elements to the measuring and recording instrument in the deckhouse, where the information appears as lines on a moving roll. This type of measurement is used mainly for investigating water movement in estuaries.*

Current meters of the Ekman type may be suspended at intervals on a long cable and in this way measurements may be made at various depths from the surface to the bottom. Special weights sent down the cable will release trigger devices so as to start and stop the meters at precise times, after lowering the cable and before hauling it back to the surface. Variations of this type of meter are also designed so as to make mechanical records, or to record current velocity and direction on the deck of the ship by electrical means.

Among the ingenious devices applied to current meters are those designed to keep the recording or electrical parts in a waterproof housing. One type of meter, designed to operate for long periods without attention, has the propeller outside of the main

RED TIDE

This is one of several hundred cards released along the West Coast of Florida for the study of currents in connection with the *Red Tide*. Your cooperation in giving accurate information and returning the postage-free card will be greatly appreciated, and will be very beneficial to you and your neighbors.

Date and Time found ....

Where Found ....

(Name of Beach, Key, Place on shore, near what city, or other prominent reference point. OR, if at sea, exact latitude and longitude.)

Name and Address of Finder ....

....

....

....

THE BACK *of a prepaid postal card used in drift bottles and in pliofilm envelopes for investigating currents in their relation to Red Tide.*

instrument. Instead of a shaft entering the instrument through a watertight seal, the propeller carries a magnet. As this rotates it actuates the recording mechanism within the watertight shell, so that no shaft need penetrate and the problem of a seal resistant to the high pressures of deep water is sidetracked. Some instruments of this type are designed so that at regular intervals of time part of a strip of photographic film is exposed, while a light illuminates the dials showing the time and the velocity and direction of current. In an instrument developed at Miami for leaving unattended on the bottom of bays and estuaries, the photographic record also includes the salinity of the seawater measured by its density, and the tidal depth of the water.

There are simpler devices which tell the speed of currents at the surface only. These depend usually upon the drag of a float upon a pendulum or cable, which is pulled at an angle from the vertical according to the speed of flow. For measuring current at various depths the more complicated meters are needed. Even here the problem arises of the back and forth motions of the vessel as it rides to it anchor, especially in deep water. Fortunately, the motion of the ship is rhythmical in nature and can be subtracted from the meter records by careful analysis.

Drift Bottles & Floats

When measurements are needed over a wide area anchored ships do not offer a practical solution and, instead, use is made of drifting bottles or floats. The simplest observation of this kind must have been the discovery of tropical woods or fruits on European shores, which indicated that currents reaching Northern Europe must have originated in the tropics and to the west. Perhaps this influenced the Norse explorations long before the time of Columbus. Today various types of floats are set free upon the water so that when recovered they may indicate something of the nature of the currents which

carried them. Glass bottles with addressed postcards and directions for filling out details of time and place of recapture have long been used. Some types of bottles are weighted and have a wire trailer below so that they will drift just clear of bottom obstructions and be carried by bottom currents.

Drift Cards

An interesting variation in the use of drifting floats is the drift card, which consists of the usual information postal card enclosed in a transparent pliofilm envelope, so that it floats. During investigations of the Florida Red Tide, The Marine Laboratory of the University of Miami used thousands of these cards. They were distributed from a fleet of private motor boats in such a way that very large areas of water were covered and when picked up by the same fleet some days later an unusually detailed picture of the complicated system of currents and eddies off the west coast of Florida was obtained.

The interpretation of float records is full of difficulties, since any one bottle, card, or float can only tell the beginning and end of its course and the time taken. It does not show whether the course was direct or indirect. An example of this was given by Dr. Tait in his study of the North Sea Currents in relation to fisheries. Bottles released at one place were picked up near the coast of Jutland at various times. The times taken for them to reach the place where they were picked up were in multiples of twenty days. The explanation was that there is a big eddy off the Jutland coast and that the circulation time of the eddy is about twenty days. Some bottles completed the course once, but others went around twice or even more before being picked up.

Radio Floats

As electronic devices are being more and more applied to oceanographic problems and instruments today, it is not surprising to find the drift buoy or float undergoing its own kind of evolution. Floating buoys, with deep keels or weighted poles to minimize wind action, are now equipped to send out radio signals which carry information about water temperature as well as signalling their changing positions. Surface vessels are thus able to follow individual floats at their will, simply by "homing" on the radio signals. Another type of float works in reverse, as it were, by having a staff and metal flag which acts as a radar target, so that the research vessel may find its free floating buoys on its own radar screen. This system obviously suffers from being unduly subject to the effects of wind on the target. Still another type of free floating buoy, developed at Miami, has a lightweight anchor and cable. At the end of a specified period, say thirty hours, a clockwork mechanism trips the anchor, thus mooring the float and erects a radar target, previously folded down out of wind action.

So far we have considered the more or less direct ways of measuring ocean currents but there are some interesting properties of sea water

SAMPLES OF SEA WATER *used in the measurement of ocean currents are taken in special steel containers known as Nansen bottles. A series of these, open at each end, is lowered on a cable to the required depth. Weights are then sent down the cable which release one end of each bottle so that it turns upside down, at the same time closing each end so as to trap water from the required depths. Thermometers may be seen in metal tubes attached to the side of the bottles for measuring the temperature at each depth.*

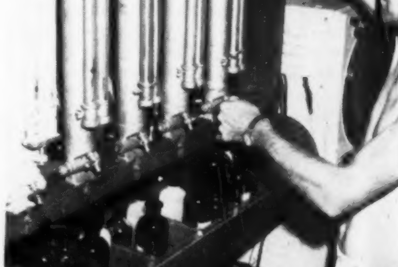
which make it possible to use indirect methods, involving, odd as it may seem, tide gauges, thermometers, electric currents and even chemical analysis. Only by means such as these is the oceanographer able to compute more or less accurately the volume of water flowing in the sea which, in the case of the Gulfstream, is many hundred times that of the river Mississippi in flood.

Electromagnetic Measurement

An old principle has been recently applied to the measurement of currents. This is based upon the electromagnetic properties which underlie the dynamo from which we obtain our electricity for power and light. When an electrical conductor moves across a magnetic field, then an electric current is developed in the circuit containing the conductor. The faster the conductor moves the more electricity is produced. Pretty much the same thing happens when sea water, itself a conductor of electricity, moves across the earth's magnetic field. And so, by measuring the small amounts of electricity produced at sea, we have a means of measuring the rate of flow of the water. For this purpose two stationary electrodes may be placed at suitable distances apart and the electrical flow between them measured. Or they may be towed behind a ship. In each case they measure the water flow between and at right angles to the line joining the electrodes, independent of the ship's speed. The instrument used at sea today, including a potentiometer, which records the speed of water current continuously on paper, is known as the G.E.K., or to be more exact the geomagnetic electrokinetograph. When the method was originally tested in England by Faraday from a bridge over the River Thames the results were not satisfactory but in more recent years Longuet-Higgins and subsequently Von Arx have developed a satisfactory system. A remarkable feature of this method is that under some conditions the measurement of water currents may be carried out without even leaving the shore. Since the electrical field caused by currents extends beyond the edge of the water the electrodes may be used on land where they measure the speed of water from the terrestial part of the electrical field.

Water in the open sea is not exactly the same from top to bottom. As mentioned previously, sea water is lighter when it is warmer and

AN IMPORTANT METHOD *of measuring ocean currents depends upon careful analysis of the salt content of the water, as explained in the text. The illustration shows an oceanographer removing samples of sea water from steel sample bottles for chemical analysis.*



fresher and heavier when it becomes cooler and saltier. As might be expected, when undisturbed by currents or mixing processes, the surface layers of the sea will be lighter and successively deeper layers will be increasingly heavy. The exact density can be calculated from the temperature and salinity. When a current flows, however, there is a readjustment of the distribution of density in the water to compensate for the earth's rotation, which exercises an effect on moving bodies known as the Coriolis force. The effect of this is to shift the heavier water towards the left of the current when looking downstream in the northern hemisphere. The degree of this shift is proportional to the current. The oceanographer can therefore calculate the flow of a water current at sea provided he knows the way in which the water density is distributed.

For practical purposes, the research vessel steams at right angles to the current, stopping at intervals to make the necessary measurements. At each station a cable is sent down with a number of water sampling bottles attached to it at appropriate intervals. The Nansen bottles, as they are called, are made of steel tube, and are sent down with both ends open so that the water runs through them. When each arrives at its proper depth messenger weights are sent down the cable so as to trip a trigger mechanism which turns the bottle upside down on its hinged attachment to the cable, while at the same time closing it. The temperature is meanwhile measured by means of a sensitive thermometer,

A HEAVY STEEL BOTTLE *crushed flat by the pressure in deep water. This Nansen bottle, shown by Dr. Luis Howell Rivero, Cuban oceanographer, was flattened when a technician accidentally attached it to the cable with the ends closed and lowered it to 1,000 fathoms. In normal use the bottle is open at both ends when the cable is lowered, so that the pressure is the same inside and out.*

attached to the bottle, which automatically records the temperature registered at the time it is upended. The saltness of the water is measured by chemical analysis of the sample brought back in the bottle.

The thermometer used is guarded against the pressure of water by being enclosed in a protecting tube. A second thermometer is carried on the Nansen bottle for the surprising purpose of measuring the depth at which the sample is taken. In order to do this this thermometer is not provided

with a protecting tube. As a result the water pressure causes the bulb to be slightly compressed and so the thermometer registers higher than it should. The amount of pressure and therefore the depth of water can be calculated from the difference in reading of the two thermometers.

Another consequence of the way in which the Coriolis force causes a redistribution of water density enables changes in the flow of ocean currents to be measured by means of tide gauges. Since the heavier water shifts to the left of the stream, the water surface tilts in order to maintain equilibrium so that the right hand edge of the stream is higher than the left. For instance, the Atlantic circulation, including the Gulfstream, flows in a circuit with the Sargasso Sea near the center. On all sides, therefore, there is a downward slope of water from the Sargasso Sea outwards. In the Florida Straits this means that the water level at Miami on the coast of Florida is around two feet lower than it is at Gun Cay on the Bahamas side of the Straits. This downhill gradient increases when the current increases, so that comparison of tide gauge records at the two places enables the oceanographer to detect changes in the pace of the Gulf Stream, after averaging out the tidal movements, of course.

Aid to Yachtsmen

Yachtsmen in the Newport-Bermuda ocean race go to sea equipped with water thermometers, not through an enduring interest in oceanographic science, but for navigational reasons, since they are able to judge when they enter the Gulf Stream by changes in the surface temperature. Since there is relatively less change in saltness than in temperature in the open ocean it follows that the density distribution is more noticeably reflected in the temperature of the water. For this reason there is a rise of temperature as a ship enters the Gulf Stream from the American side.

Vertical Currents

Mention has been made of vertical currents and the huge slow movements of water deep below the surface. The measurement of these presents a different kind of problem to that of surface currents and so other methods must be used. An obvious approach, of course, is to add up the volume of water flowing into and out of any particular ocean or body of water. When the surface currents are known and hence reliable estimates can be made of the vertical movements, then a balance may be struck and the residual amount of flow must take place below the surface. A water budget, in fact, is set up. Other methods are used, involving the measurement of carbon isotopes in the sea. The ratio of the carbon 12 and carbon 14 atoms in the water varies according to the length of time it has been away from the surface so that isotope measurements provide a measurement of the water movement. Other approaches involving changes in oxygen concentration, in temperature and salinity have been used and will be described it is hoped in a future article.

IN OCEAN RACES TODAY *more and more yachtsmen are taking advantage of the fact that temperature changes take place at the sea surface in relation to the position of ocean currents. This has been especially true in the Newport Bermuda race which crosses the Gulf Stream, variable in speed and position. The illustrations shows COMANCHE leaving JUBILEE at the start of the Lipton Race this year, sailed in the Florida Current, at the headwaters of the Gulf Stream.*

A WATER STRIDER. *The seagoing water insect,* Halobates sericeus, *one of a strange group of insects that is found on the surface of the ocean, far from land. The illustration shows a male insect and is about 25 times its natural size.*

Treaders of the Sea[1]

By J. L. McHugh
Virginia Fisheries Laboratory

and Hilary B. Moore
The Marine Laboratory, University of Miami

The ocean is never still. On those rare occasions when its surface is unruffled by the wind there remain the long, slow oscillations of the perpetual swell, and the steady drift of the great oceanic currents. The alert marine biologist will never miss the opportunity, when the ship is hove to on a still, dark night, far at sea, to observe and collect the marine animals that drift past, or are attracted to, a light suspended close above the smooth water. His attention may not be rewarded by the variety and abundance of life that gathers round his lure in inshore waters, but his catch will include exotic things that his shorebound colleagues meet only in books or in bottles.

Of all these animals, none is more fascinating than the little water strider *Halobates*. Disappearing mysteriously when the first gust of wind disturbs the surface, but darting here and there across the surface calm, these "treaders of the sea" soon reveal themselves as insects by the startling similarity of their movements to the familiar swarms about a summer street lamp.

Our natural surprise, on our first discovery of *Halobates* some 400 miles off the California coast one still night in November, aroused our curiosity. How came these little insects to a rendezvous so far from shore? How do they survive the furious Pacific storms? How do they feed, mate, deposit their eggs, and breathe? As we half-expected, knowledge of their life cycle is quite incomplete. Some twenty different kinds are known, all members of the water-strider family that includes the familiar pond-skaters of fresh water. But these are the only insects that pass their entire existence at sea.

It is a remarkable reminder of man's short acquaintance with the open ocean that the first written account of these insects probably appeared not much more than a hundred years ago. Robert Templeton, in 1836, said:

"This beautiful species was captured nearly midway between the continents of Africa and America, by Colonel Streatfield, 87th R. T. F., whose name I have in consequence done myself the favour to affix to it, as being most appropriate, and as a slight testimony of the grateful recollection I have of his kindness in presenting me with many interesting species of insects and other rarities. The sea was quite smooth, with a gentle swell, at the time the inseet was caught; a number were swimming

[1]Contributions from the Virginia Fisheries Laboratory, No. 61.

about among the Porpitae, which formed the first object of attraction, and fortunately directed attention to the insect. The singularity of its distance from any land, and the possibility of its being driven off from the African coast by the south-eastern gales, gave full play to conjecture, and excited our attention to the little creatures in the water, in the hope of ascertaining on what objects it preyed; but all possibility of discovering this was quickly put a period to by the S.E. trade sweeping over the surface and banishing all traces of the Medusae and their companions."

Robert M'Lachlan, F.R.S., wrote in 1860-71:

"These notes have a peculiar interest for me, as exciting reminiscences of a voyage of thirteen months' duration I made when a youth, in 1855-56. This voyage was marked by a most immoderate amount of calms (in one case extending to thirty consecutive days, in the hottest part of the China Sea), and I lost no opportunity of fishing up—and, I am sorry now to say, casting away,—the, to me, wonderful forms always floating around. Long before crossing the line, on the outward voyage, I was struck by small whitish creatures which often appeared coursing with great rapidity over the surface of the ocean; at length one was captured, and I well remember my astonishment on finding it was a spider-like insect, of the affinities of which I then knew nothing. They disappeared, or rather were lost to view, as soon as a breath of wind caused a ripple on the surface, but were common in that most unpleasant form of sea-disturbance in which there are great 'smooth' waves, the effect of a recent storm, but with no present wind. In the Atlantic, Indian, and Pacific Oceans it only needed the required state of the sea to bring these merry coursers to view, and certainly often with the presence of the smallest piece of floating sea-weed. Those who have voyaged will bear me out when I say that, excepting in the mysterious Sargasso-sea, in the course of the oceanic currents, and in the vicinity of land, seaweed may be looked for with as much chance of finding it as daisies. I should here state that the brilliant white appearance of the insect on the ocean is caused by the pellicle of air that surrounds it, the creature itself being blackish. If these notes should be read by any one of those 'who go down to the sea in ships', I would remind him that, if he can throw any light upon the life-history of this most wonderful insect (how many species there may be I know not), he will confer the utmost benefit upon natural science."

Riding Out Gales

When even moderate winds disturb the surface, the observer can place neither his lamp nor his eyes near enough to see these acrobats against the confused background, and it is small wonder that others have assumed that they plunge beneath the surface to escape rough weather. Yet Robert Usinger has described a Hawaiian species that jumps but never dives. Those that we have captured at sea leap with surprising agility. The water striders are not noted for their ability to dive or to remain submerged for long periods, and, as any mariner can testify, an oceanic insect would find it necessary to remain below both long and deep to escape the long-lived, furious storms that sweep the oceans. We prefer to believe that *Halobates* rides the surface in all weather, leaping to safety when a breaking wave threatens, or, if caught unawares, returning to the surface immediately.

In common with all the true bugs, *Halobates* possesses mouth parts that

are made for sucking. It has been said that this bug feeds upon the bodies of small marine animals recently deceased, or upon the juices of jellyfishes, but there is no reason to doubt that it also seizes living animals. Some are described as fiercely cannibalistic.

The insects are often quoted as the most successful of all groups of land and fresh water animals. It has been estimated that some 625,000 kinds have already been recognized and that there are probably two to four million kinds actually in existence. Yet the sea has hardly any, and these few mostly in the intertidal zone. The water striders are therefore in their small way, some of the most unusual of marine creatures.

Man Made Water Striders

In recent years a novel type of craft has been developed, first of all in Switzerland, and later in the United States and elsewhere, that bears a strange resemblance to a water insect. These craft, known as hydrofoil boats, are equipped with horizontal planes or foils attached to struts extending below the keel. By adjusting the angle of the hydrofoils to maximum lift the boat under power is raised by them and actually leaves the water until it is supported only by the foils, like an insect on legs. One such craft, being developed in Miami, Florida by the Miami Shipbuilding Corporation for the U. S. Navy, has been named, appropriately enough, *Halobates*.

One of the advantages of this type of craft is the considerable reduction of water friction which results in higher speeds. Use of hydrofoils with angle of attack adjustable to the uneven sea surface also reduces the pitching motion of a boat. Antenna-like devices which enhance the insect-like appearance, project ahead of the boat and react to the oncoming waves by changing the angle of attack of the hydrofoils. Hydrofoil boats have been developed to a sufficient extent to enable them to be used on the Swiss lakes as a regular passenger boat. It is interesting to note that the hydrofoil does not act like the planing surface of a high speed boat, but like the wing of an airplane, so that most of its lift actually comes from the upper surface.

HYDROFOIL BOAT. *The hydrofoil boat looks for all the world like a seagoing insect but is actually designed on the principle of an underwater wing surface which lifts the hull, as an airplane wing does. As far back as 1907 the Wright brothers experimented with hydrofoil boats and today there is a renewed interest in this type of development.*

RARE VISITORS TO NEW ENGLAND WATERS, *although very common off the British Isles, are the strange looking angel sharks. This was caught by Rowland Babbitt of St. Judith Fisheries, Point Judith, Rhode Island, last year.*

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The Amazing Angel Shark

By BERNARD L. GORDON

DID YOU ever see a fish shaped like a bass fiddle, with pectoral fins resembling an angel's wings and whose body is flat and depressed similar to a skate? Well, a fish answering this description was caught this past January fifteenth with a haul of tilefish and fluke in an otter trawl by the fishing dragger *R. W. Griffin, Jr.* out of Woods Hole, Mass., captained by Warren Vincent.

This strange sea creature was taken in fifty-five fathoms of water about one hundred miles south of Block Island. Skipper Vincent landed his catch at Point Judith Fisheries where George B. Gross, president of the firm, notified Dr. Charles J. Fish, director of the Narragansett Marine Laboratory of the University of Rhode Island. Dr. Fish identified it as an angel shark (not to be confused with the angler or goose fish) and said that it was the second one of its kind to be recorded in Rhode Island waters during the eighteen years he has been director of the laboratory.

The weight of this angel shark, also known as a monkfish, was twenty-two pounds and it was three feet long. Nichols and Breeder mention two monkfish taken in the traps of Menemsha Bight, Martha's Vineyard. One of thirty-five pounds, four feet long on September 1, 1873, and another three feet seven inches long September 23, 1921, identified by Francis West. There is also a record of one from Lynnhaven Roads, Virginia pound net, July 15, 1916.

The common monkfish or angel shark *Squatina dumeril* is found in the Atlantic, from Southern New England to Florida, the Gulf of Mexico and Jamaica. The European monkfish, *Squatina squatina* is known from Northern Europe to the Mediterranean. Other similar species of the same family are found off the shores of Peru, Chile, Mexico, California, Australia and Japan. In Europe it is sometimes called fiddle fish, monkeyfish shark and shark ray.

Shark or Ray?

From its general appearance the angel shark closely resembles a ray or skate. This is brought out by its local name of mongrel skate and shark ray. A close study of its internal anatomy shows it to be a true shark. This finding is confirmed by the location of its external gill clefts on the side of its head.

A further argument in favor of placing the monkfish with sharks rather than the skate is provided by its method of swimming. It propels itself by means of a powerful sculling action of the oar-like tail and it makes little or no use of its large pectoral fins for this purpose.

Angel sharks reach a maximum length of eight feet but are usually considerably smaller. The base of its

pectoral fins projects to form angular shoulders free from the head and body.

The backside color of this fish is a brownish grey tending toward olive drab with the belly surface plain white. Its eyes are small and located on top of the head. The mouth is near the end of the rounded head and equipped with several rows of sharp pointed teeth which are set apart one from another. Its spiracles are large and crescent shaped a short distance behind the eyes.

Fossil remains of *Squatina* date back to the Jurassic and Cretaceous periods, and the well-preserved remains in the Lithographic Stone of Bavaria reveal angel sharks which are indistinguishable from their descendants which are living today.

This species of shark has somewhat of a historical reputation as a half human monster of the deep. A. Hyatt Verrill in his book *Strange Fish and Their Stories* quotes Rondelet, a French ichthyologist, as describing a monkfish in 1558 that had washed up on a Norwegian beach during a storm at a place called Dreze near the town called Denelapoch. "In our time in Norway, a sea monster has been taken after a great storm, to which all who saw it at once gave the name of monk. It had a man's face rude and ungracious, the head smooth and shorn. On the shoulders, like the cloak of a monk, were two long fins in place of arms, and the end of the body was finished by a long tail."

Otto Lugger in the Report of the Commissioner of Fisheries of Maryland (1878, pg. 122) says of the angel shark: "The not very inviting looks of this fish are not the only reasons why fishermen dislike it. It has, to some extent, the unpleasant habits of the snapping turtle, since it can open its mouth very suddenly, to an alarming extent, and not to play, either. In consequence of this biting propensity, it is called by the fishermen the 'sand devil' and also the 'fair maid'; the first name not without any reason and the latter certainly not out of politeness."

The food of the monkfish is similar to that of the skate and its normal diet includes crabs, snails, small flatfish and other animals found on the sea floor. One female examined was found to have in its stomach several dabs and plaice, portions of other fish, scales of mullet, not less than fifty fish eyes and a fair size bundle of eel grass. On occasion the monkfish may be a very voracious feeder, there is a record of one fish coming to the surface and seizing a living cormorant by the wing and holding it below the surface until it drowned. There is another record of one which swallowed a lady's hat; a two pound can of mustard was found in the gut of another; and perhaps the oddest item found in an angel shark's stomach was a piece of wood eighteen inches long and twelve inches wide studded with nails.

The monkfish spends the winter offshore in rather deep water and approaches the coast in the spring for breeding purposes. The young are born alive generally in June or July and as many as twenty-five baby

monkfish have been recorded at a single birth.

The flesh of angel shark is rather coarse and was formerly despised as food. However, in England an increasing amount of these fish are landed each year, the majority of these going to fried fish shops. In olden times the rough skin of the angel shark, called shagreen or chagrin, was much used as an abrasive to polish wood and ivory. The skin itself was dried and crushed up for medicinal purposes, being prescribed as a sovereign remedy for the itch and other skin complaints.

Bigelow and Schroeder in their *Fishes of the Gulf of Maine* do not record the angel shark, but it has been found off Martha's Vineyard and Block Island. More recently Bigelow and Schroeder have recorded it in *Fishes of the Western North Atlantic*, in the section on sharks, giving excellent figures, descriptions, habitat and sizes.

Science of the Sea in Books

CREATURES OF THE DEEP SEA

KLAUS GUENTHER AND KURT DECKERT, translated from the German by E. W. DICKES. Charles Scribners Sons, New York, 1906. $3.95.

The original German work has been of considerable interest to biological oceanographers since it first appeared and the English translation will therefore be welcomed by investigators and students. It should also appeal to the general reader since it is a book in which illustrations and descriptions of the many strange and fantastic deep-sea creatures are brought together from the scattered sources in which they were previously available. A number of technical terms are used but they are well explained in the text, so that only a general scientific background is needed by the reader who wishes to follow it closely. The many illustrations alone should recommend it to the general reader. It should also be on the shelf of every student of marine biology, since the discussions of the why and wherefore of the peculiar form and behavior of the strange life of the deep seas are good, in spite of a few technical errors.

One of the problems of describing scientific matters to the general reader is the translation of technical terms into everyday language. The crabs, lobsters and related crustacea, for instance, are collectively named the Decapoda. This is here expressed as "the tenfooted crabs" which is neither clear nor correct. On the other hand the authors have given the best and clearest available description of a complicated mechanism, namely the telescopic jaws of some of the deep-sea fishes which enables them to swallow victims larger than themselves.

The extraordinary range of grotesque life in the deep sea is completely unknown to most people and this book will certainly open up a new and strange world of real monsters to those whose acquaintance with the deep sea has been limited to crossing it or to reading the all too frequent accounts of doubtful and fictitious monsters. Truth here is stranger by far than most fiction.

HANDBOOK OF TROPICAL AQUARIUM FISHES

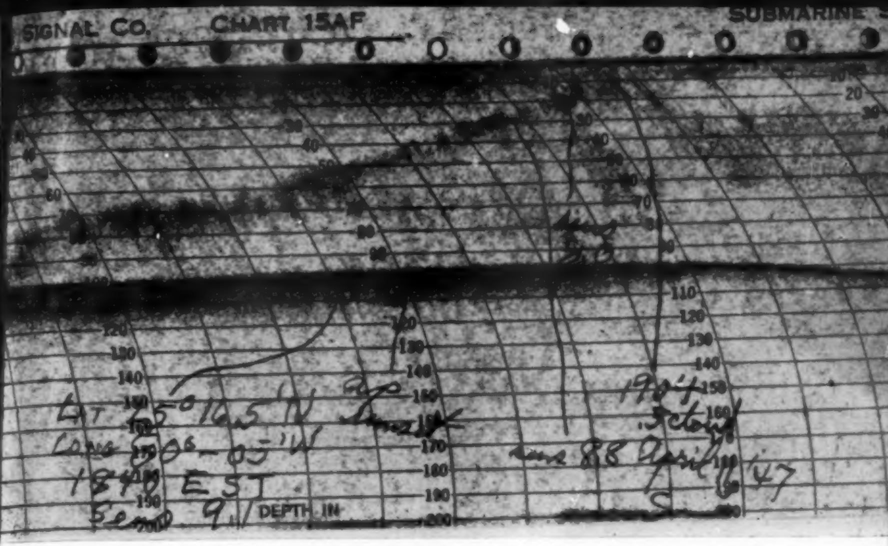
HERBERT R. AXELROD AND LEONARD P. SCHULTZ. McGraw Hill. This is a scientifically accurate handbook for all interested in keeping aquarium fishes, and is perhaps the most complete of its kind. In addition to a careful catalogue of these fishes, it includes a well written account of history of ichthyology, methods of collecting fishes, their distribution, structure, habits and behavior suitable for the general reader. Sections on marine fishes and aquaria are included and the whole is well illustrated.

MAN AND THE UNDERWATER WORLD

PIERRE DELATIL AND JEAN RIVOIRE. G. P. Putnam's Sons, New York, 1956. Enthusiasm for underwater activities today has become widespread and is no longer limited to the purely passive reading of books about the sea. The great army of skin divers, in particular, has a direct interest in the mechanical aspects of diving and should welcome this book which is largely a history of the development of diving equipment. But it is more than a simple historical survey. It is a fascinating story of the experiences of divers of all ages, not neglecting those of Greece or Rome nor the schemes of Middle Age inventors such as Leonardo da Vinci. Fact and fancy, the ancient legends and modern knowledge are covered in this well illustrated book.

OF WHALES AND MEN

R. B. ROBERTSON. Alfred Knopf, New York, 1956. Although published two years ago this book has now, and deservedly, been made a book club selection. It is recommended reading both for the general reader and for marine scientists who are interested in knowing more of the modern whaling industry. The book is a vivid account of personal observations written by the physician on board the factory ship. It gives a detailed and graphic description of the entire operation of a whaling fleet from catching to processing. It also includes the most complete set of measurements ever made of the internal organs of a whale. Above all it is an exciting account of a unique experience. Among the surprising facts disclosed is that whale factory ships in the Antarctic bring as much as $180,000,000 to Great Britain annually and that one operation may make a profit to the owners of around $10,000,000 in a single eight-month voyage. Most of the eleven fleets sailing to the Southern Ocean each year were British. Although the factory ship engine room crews were Scotsmen and the deck crew Shetland Islanders, all of the crews of the catchers—the fast harpoon boats — were Norwegians with one exception. This man, the champion among them, was a Swedish ex-taxi driver from New York.



THE VERTICAL MOVEMENTS OF PLANKTON *revealed by sound. This echo-sounder record was made just south of Miami at sunset. The bottom shows at 100 fathoms. Just before sunset a shoal of unidentified animals leaves the bottom, moves up to the surface, and then diffuses down again when there is too little left to hold it there.*

Ups and Downs at Sea

By HILARY B. MOORE
The Marine Laboratory, University of Miami

WE ARE SO USED to the daily rhythm of day and night, of light and dark, that we are apt to take it for granted. We forget how much our habits are moulded by it. But if we think back to the days of primitive mankind we will find that our ancestors were active during the day but retreated to a sheltered place to sleep during the hours of darkness. Modern man does not always follow this precept of "early to bed and early to rise . . . ", mainly because he has been able, artifically, to turn the night into day as far as he is concerned. But the rest of the animal kingdom has no such ability. Animals must take things as they find them and so they usually obey a simple routine which follows the changes in the light from the sun. Some are active in the daytime and sleep at night when it is dark and colder. Others sleep all day and emerge only at dusk to pursue the business of feeding. But both have a rhythm in their movements.

It is characteristic of animals that they can move about—most of them have to, in order to find their food. Movement is just as important to them, though, as a means of seeking the conditions that best suit their living needs and of avoiding those that are harmful. We see an extreme example in the spring and fall mi-

A SAMPLE OF PLANKTON *taken near Miami showing jellyfish, siphonophores, a transparent salpa (upper right), pteropods, arrowworms and various kinds of crustacea and young fish.*

grations of birds. On a smaller scale, great numbers of other animals are regularly on the move under the urge of changing climate. The migrations do not have to be extensive. The distance from under a dead leaf out into the open may make all the difference to an insect in need of protection from the hot sun.

Marine Migrations

The sea, too, has its spectacular migrations. Whales feed in the plankton-rich waters round South Georgia in the antarctic summer, but they trek up to the South African coast for the winter. Some of the oceanic birds travel even further, the Great Shearwater nesting on Tristan da Cunha, travelling each year up the Gulf Stream and across the North Atlantic to return down the European side. On the smaller scale, in the barely visible creatures of the sea, we find migrations which are just as spectacular. A copepod in the plankton, less than a quarter of an inch long is, for his size, making a tremendous journey when he swims up a hundred fathoms to the surface every night. In terms of his own length this is as if he swam over thirty miles. What is more, the copepod makes this trip in a few hours only and swims down again the same distance next morning.

Empty by day, crowded at night

The land animals which avoid sunlight too bright for them may find suitable shade close by. They may not have far to go to find a shelter under a stone, or down a burrow. There is no such shade in the open sea and the only way to get away from the light is to swim down to a depth great enough for the harmful rays to have been absorbed. In the clear waters of the Sargasso Sea, this may be a long way down. It is one of the most striking phenomena in the ocean's populations, that the upper layers are almost deserted in the daytime. True, there are a few animals which seem to like the bright light, but the great majority cannot stand it. In fact, many of them die if they cannot get away to more somber regions.

At first sight it would seem that such creatures have an easy solution to the problem. Why can they not live permanently at a depth of a few hundred fathoms, where the light will never get too strong for them? It is true that some of them do, like shade-dwellers of land. But, unfortunately, this would take most of them away from their food supply. The microscopic plankton plants, which are the basic foodstuff of the oceans, need light in order to grow. It is up nearer the surface that this vegetation flourishes, and, naturally, this is where the small grazing creatures congregate in order to feed. And, of course, if the grazers or herbivores move up into the feeding grounds, the carnivores which prey upon them will follow.

Commuters at Sea

So, we find an endless pendulum swinging in these upper waters, the plant eaters hurrying towards the surface as the evening light allows them and the predators following along; and then, after a busy night of feeding, the whole pack retreats to

the dimmer depths as the rising sun begins to illuminate the sea.

The Scattering Layer

The herbivores are mostly pretty small, but the carnivores range right up to the big oceanic fishes, so there is a whole animal world on the move. So spectacular is this migration that we can pick it up on our echo sounding machines—designed for finding the depth to the bottom—and record it as a steadily shifting band on the paper—an echo from all the mixture of animals that is down below the ship. This is called the scattering layer, since it scatters sound impulses. Before it was well understood, such echoes even gave rise to reports of shoal water where none was supposed to exist, and more than one survey ship has been sent to investigate what was no more than a concentration of plankton and fishes.

Built-in Instruments

We, on a research vessel, have elaborate instruments to measure the light, the temperature and the pressure in the depths of the sea. A copepod, an eighth of an inch long, must carry a built-in mechanism to give it the same information. What is more, it must be able to weigh one changing condition against another and settle for a compromise that will suit its individual needs. If it goes too deep in trying to avoid the light, it may find the water too cold or the pressure too great. One way and another, we are beginning to understand a little of how the plankton senses the conditions around it and responds as these three conditions change.

At the Marine Laboratory in Miami these creatures are being kept alive in the laboratory in order to find how they react to light, dark, pressure and temperature. At sea we send nets to the different depths at different times of day and night to find where the various types of creatures are and what their rhythm of movement is. Gradually a pattern is beginning to unfold as the results are analyzed, often by tedious mathematical analysis. It is a long and complex story and we are only beginning to open it up, but we hope that what we learn from these simpler animals may help later in the understanding of higher forms, up to man himself.

Gamefish Reports

Those who are engaged in ocean gamefish research are invited to correspond with Dr. Gilbert Voss of the Gamefish Research Committee for the purpose of exchanging information. Anglers, especially those who are fishing in relatively unexplored waters, are also invited to send in their reports for inclusion in future numbers of the Bulletin. The Editor will be glad to consider for publication non-technical, illustrated accounts of scientific investigations in this field.

New West African Fishery

The increasing demand for food in many parts of the world, following growing human populations, is a potent stimulus to exploratory fishing operations. Mr. Derek H. Mills, of the Scottish Marine Biological Association, sends us a photograph taken during an experimental trawling survey off the Isles de Los, French Guinea. The trawl was shot from the F.R.S. *Cape St. Mary* in ten fathoms of water, only a few miles offshore. In two short hours over a ton of fish was landed.

The species included croakers, weakfish, sheepshead, threadfin and stingray. The results of this exploration should result in a new fishery in French Guinea, which lies on the bulge of the West Coast of Africa, about 280 miles south of Dakar.

Big game anglers may be interested in the discovery of this rich fish fauna, since where commercial fisheries are plentiful there may well be exceptional possibilities for big game fish. Just as in commercial fishing, big game anglers are continually seeking new, unexploited areas where phenomenal catches may be made.

Mr. Mills has worked in tropical marine research at the West African Fisheries Research Station in Freetown, Sierra Leone, and promises the Foundation an illustrated article on fishery development in West Africa.

EXPERIMENTAL TRAWLING *off the Isles de Los, French Guinea, has revealed a new fishing ground. In two hours the trawl brought to the surface over a ton of fish. One of the most important research activities in fisheries is exploratory fishing. Today this is being carried out to an increasing extent in all parts of the world and should help to increase our yield of food resources from the sea.*

THE SAIL CARRIED *by GERDA is useful in steadying the ship when trawling at slow speed or heaving to at offshore stations. It will also serve for motive power in an emergency. Nor does it detract from her appearance.*

Oceanography Recruits A Dane

SEAGOING research vessels, especially the larger ones, are not too numerous. For one thing they are expensive, both to build and to operate. For another, it usually takes several years of work by a team of scientists to analyze the observations and collections made by an expedition only one year at sea and to bring together the results and conclusions into a final report. This naturally reduces the number of offshore operations which are practically possible. And so there have been relatively few vessels of this kind and they are familiar names to marine scientists and frequently also to those with only a general interest in the sea. H.M.S. *Challenger* and H.M.S. *Beagle* are among the earliest of these (see pp. *9-12*, Vol. 1, No. 2 of this Bulletin). Some others are the *Porcupine, Valdivia, Michael Sars,* and the Duke of Monaco's *L'Hirondelle,* to name only a few. Today the number of vessels capable of long interocean voyages is not even counted in tens.

Among European vessels are the French *Theodore Tissier,* and the British *Discovery*. In the United States are *Atlantis,* built in Denmark for the Woods Hole Oceanographic Institute, and the *Howard W. Scripps,* belonging to the Scripps Institute of Oceanography of California. Some ships recently employed in scientific research have only been chartered temporarily, for specific expeditions, such as the Danish *Galatea,* and the Swedish *Albatross* deep sea expeditions (see pp. *9-16,* Vol. 2, No. 1 of this Bulletin).

There is a larger but still restricted number of smaller vessels, able to work in the open ocean, but not suitable for very long voyages. One of those most recently added to the roster of seagoing research vessels is the former yacht, *Gerda.* This ship well maintains the international tradition of oceanography, since she was built in Korsør in Denmark, is now at work in the distant waters of the Caribbean Sea, the Gulf of Mexico, the westerly fringe of the Sargasso and the Florida Straits, root of the Gulf Stream, for The Marine Laboratory of the University of Miami. Brigadier General Robert W. Johnson of Princeton, New Jersey, planned and built *Gerda* as a yacht but designed her specifically to be able to support exploratory work in the North Atlantic. Her designer was Kund E. Hansen, and she was built in 1949, one of the most able and best suited vessels of her size for seagoing research. Although only seventy-five feet overall she has a beam of twenty-one feet and ten feet three inches maximum draft. Her design is akin to that of the North Sea trawler with a bluff powerful bow, a good sheer and generous midsection. Her build is such as to withstand the most vigorous conditions. Keel and stem are 8½ x 11 inches, the keel of beech and the stem of oak. The oak frames are 5½ x 6½ inches on 20 inch centers. Planking is 2½ inch beech with 2 inch oak topsides and

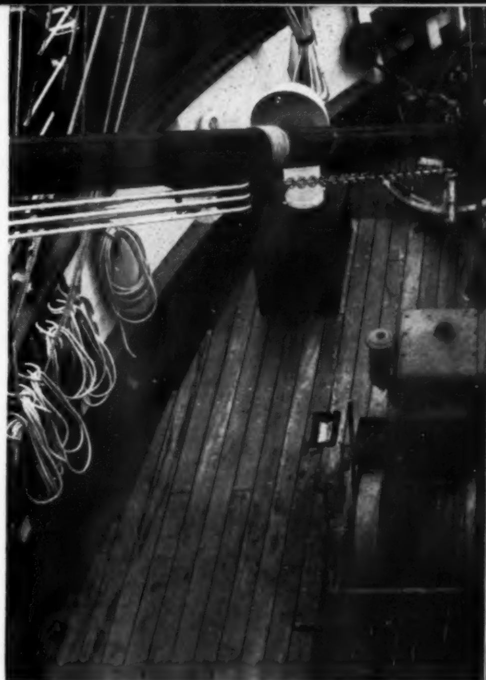
GERDA IS WELL EQUIPPED *for offshore navigation. In addition to her Sperry radar, shown above, she has loran, radio direction finder, gyrocompass and automatic pilot.*

she is ceiled throughout with 1½ inch pine. In fact she is built for heavy service.

Design Problems

The design of a research vessel is difficult since it involves, as most specialized ships do, many compromises, even if there should be unlimited financial provision for construction and operation. The amount of research accomplished depends on her ability both to keep to sea in most kinds of weather and to carry out working operations during as many days at sea as possible. Fuel, water and food capacity must be matched for maximum cruising range and the economical cruising speed should be, if possible, 10 to 12 knots at least. It is also obvious that space must be provided for storage of the varieties of scientific equipment that may be needed on different occasions. The deck space must be clear and ample for all types of gear that she may need to use, nets, hauls, bottom sampling devices, hydrographic cables, bathythermographs and so forth.

To add to the list of requirements, the modern oceanographic vessel should have electrical generator capacity for much more than the usual navigational instruments, loran radar and radio direction finder. She will need storage batteries sufficient to power the essential instruments with the motors and generators shut down, while scientists studying underwater sounds and related matters are recording the audible and beyond audible vibrations that concern them. This leaves little space for sleeping



THE INSTRUMENT *cables are led through blocks on the main boom. Sudden strains and shocks when hauling valuable gear in heavy weather are taken up by the six part aero cord accumulator running below the boom and acting as a shock absorber.*

quarters and eating arrangements. It is true that the preoccupied scientist may tolerate primitive conditions for short periods. Nevertheless both the ship's crew and scientific complement are reduced in efficiency on longer voyages if living quarters are inadequate.

Gerda, though only 75 feet overall, is unusually seaworthy for her size and well able to encompass work at sea that would be difficult for many larger but less suitable vessels. Her twin Caterpillar diesels give her a cruising speed of 10 knots. Her fuel

capacity allows her a cruising range of 3000 miles, which is sufficient to allow optimum performance in the work in which she is engaged. She also carries a short ketch rig which serves to steady her while working offshore and allows the operation of scientific gear over one additional sea state. This rig is always available for emergency use since she will make several knots under sail alone, under suitable conditions.

Within the limits of her tonnage *Gerda* well satisfies the requirement that an offshore research vessel should have adequate accommodations. A crew of four and scientific party of seven or eight are able to live with fair comfort, with ample locker space and showers. Her galley has a diesel fired stove and large refrigeration capacity. Altogether her original arrangements were such that no structural changes were needed to convert her to her present role of a working oceanographic research vessel. Her rigging needed no modification, but the addition of a 6 part ¾ inch shock cord accumulator may be of interest to yachtsmen. This runs below the main boom and is connected to the block carrying the winch cable, which in turn moves on a track. In this way the accumulator takes the strain of the cable and absorbs sudden load increases due to the surge of the vessel, or fouling of the bottom gear by obstructions on the seafloor. Instruments on board, besides radio, loran, radio direction finder, radar, gyrocompass and automatic pilot include an experimental fish finder with oscilloscope or TV type presentation. For the specialized instruments used in studying the propagation, transmission, reflection, and refraction of sound underwater, a special set of racks are installed on the starboard side of the former main cabin. Ample space is left for the mess, which is shared by the ship's crew and scientific party. The wheel house is very roomy and provides additional space for those off duty. In the wheel house are installed several special instruments, including the CTD. This continuously records on a moving chart the temperature and electrical conductivity of the seawater at various depths. For this purpose a streamlined head is attached to the hydrographic cable. It transmits the above information and also the depth at which it is towed to the wheel house recorder. Like a number of other instruments on board it was designed by the scientific staff of The Marine Laboratory. The salinity of seawater may be calculated from the electrical conductivity, so that, knowing this, scientists may determine the origin of the water through which the vessel is passing. Another valuable instrument is known familiarly as the "Geek." Its full name is geomagnetic electrokinetograph and its special function is to measure ocean currents by means of electrodes towed behind the vessel. This it can do independently of the ship's speed and the information is also recorded on a moving chart aboard the ship.

So much for the equipment of one of the latest recruits to the roster of research vessels. As to her work, scientific research of a most varied

AMONG THE INSTRUMENTS *carried by GERDA as part of her permanent equipment are the Edo deep depth recorder and an auxiliary fish finder which operates off the Edo. The latter is to the right of the illustration and was built and designed by the laboratory staff.*

character keeps her at sea almost continuously. She is used, for instance, to study the periodic and disastrous growth of poisonous plankton in the Gulf of Mexico, known as Red Tide because of the discolored water that accompanies the wholesale death of fishes. Much of her time is spent in attempting to obtain a better knowledge and understanding of variations in the speed of the Gulf Stream and the relation of these to basic causes. A related study attempts to measure the amount of water and of heat carried by the Stream from tropics to what would otherwise be a much colder North Atlantic. This kind of work takes her into the Caribbean Sea as well as the Straits of Florida and the Gulf of Mexico.

Food Production of the Sea

Some of *Gerda's* time is taken up with the study of basic production in the sea—how much plankton is produced in how much time and what is the potential food supply for fishes. Among other things, this work involves the careful chemical analysis of seawater for the amount of natural chemical fertilizer in it, the concentration of phosphorus compounds for instance. This and some other chemical operations must be made at sea. The converted main cabin has therefore been designed so that it can be used as a seagoing chemical laboratory at times when it is not being used as an underwater sound laboratory or for processing plankton and other biological material.

Arrangements for biological work at sea are equally varied and flexible. The especially microscopic life known as nannoplankton is sampled by means of a pump and weighted hose which may be let down to predetermined depths. Larger plankton is sieved from the water by means of conical silk nets towed at various depths and equipped with recording devices to show the precise depth from which the sample comes. Larger mesh nets, with wide circular mouths, are used to collect the young stages of fishes. In some operations a whole string of nets may be sent down on the same cable so that they fish at different depths. Before being hauled to the surface these nets may be closed by means of trip weights sent down the cable to actuate a specially designed closing mechanism. For catching fishes up to several hundred pounds in weight a special drifting line may be used from one mile in length upwards and with from one hundred to several hundred baited hooks.

Marine research, being the exploration of unknown or little known matters, has a minimum of routine and is by nature highly diversified. For this reason an oceanographic research vessel requires to be adaptable to a number of different operations. These and the other considerations mentioned before must be taken into account when such a vessel is designed. *Gerda* satisfies them so well that she might almost have been designed for her present work from the start. May she have many years of useful and productive work in the exploration of the ocean frontier of science.

Meetings

Meetings, especially those of an international character, concerning any aspect of marine research, will be given advance notices in future numbers of the Bulletin. Chairmen and organizers of such meetings are invited to send notices to the Editor as much in advance of the meeting as possible.

Conference for Anglers

Nassau, in the Bahamas, will be the place and November 26 to 30 the dates for an international meeting of interest to big game anglers, scientists and those concerned with the commercial fisheries of this area. Most of the meeting will be concerned with commercial fishery problems of exploration, technology, marketing and biology. One day has been set aside, however, for a conference between anglers and scientists on the marlins, spearfishes and tunas of the world. Those who wish to attend should write to Dr. Gilbert Voss, The Marine Laboratory, University of Miami, 439 Anastasia Avenue, Coral Gables 34, Florida, U.S.A.

Commercial Fishery Conference

The above meeting will be held during the Gulf and Caribbean Fisheries Institute, an annual conference of fishery scientists, members of the industry and government fishery officers from the West Indies, Bermuda and the Gulf of Mexico states of the U.S.A. It is anticipated that delegates representing the British, Dutch and French islands will be present, as well as those from Cuba, Venezuela and the U.S.A. Among them will be fishing boat designers, experts in the processing and transportation of fish and shell fish and others interested in the exploration of the Caribbean Sea for new sources of supply and new high seas fisheries.

Those wishing further information should write to The Secretary, Fisheries Institute, University of Miami, Coral Gables, Florida.

Wildlife Conference Sessions on Marine Resources

Lloyd W. Swift, Technical Sessions program chairman for the 22nd North American Wildlife Conference, announces that chairmen have been selected for the six technical sessions of the forthcoming international conservation conference, which will be held March 4-6, 1957, in the Statler Hotel, Washington, D. C., according to the Wildlife Management Institute, which is the sponsor of these large annual meetings.

The three-day North American Wildlife Conference consists of three general and six technical sessions devoted to various subjects. Dr. Clarence P. Idyll of The Marine Laboratory, University of Miami, Coral Gables, Florida, will be chairman of the conference on Marine and Coastal Resources, which meets Tuesday morning, March 5.

About the Authors

ROBERT W. ELLIS

Mr. Ellis graduated with a bachelor's degree in zoology in 1948 from the University of Edinburgh in Scotland. He later worked for five years at the famous marine laboratory in Aberdeen, Scotland, investigating the life histories of important North Sea food fishes and experimenting with improvements to fishing methods and gear. Approximately one third of his time was spent at sea on fisheries research vessels and on commercial fishing boats. Mr. Ellis was later, for eighteen months, at the Newfoundland Fisheries Research Station in Canada studying similar problems.

Mr Ellis joined the staff of The Marine Laboratory of the University of Miami in March, 1955. He is in charge of the salt water gamefish survey which The Marine Laboratory is conducting for the Florida State Board of Conservation. He is also assisting in other gamefish research projects at this laboratory, including research into the snook and tarpon.

J. L. McHUGH

Dr. McHugh was born in Vancouver, British Columbia, on November 24, 1911. He received the B.A. degree from the University of British Columbia in 1936 and the M.A. in 1938. His Ph.D. was awarded at the University of California in 1950.

While attending high school and the University he worked as a summer field assistant for the Pacific Biological Station at Nanaimo from 1929 through 1937. After graduation, he joined the staff of the Pacific Biological Station as a scientific assistant and worked there until he joined the army in 1941. From 1946 to 1948 he was Research Assistant to Dr. Carl Hubbs at the Scripps Institution of Oceanography and from 1948 to 1951 was Associate Marine Biologist at Scripps. He went to the Virginia Fisheries Laboratory at Gloucester

Point, Virginia, as director in 1951. From 1941 to 1946 he served as an infantry officer in the Canadian Army in England with the Canadian Scottish Regiment and in France with the Queen's Own Cameron Highlanders. He was wounded by a sniper's bullet in Normandy in 1944 and he states that from then on his military career was a very pleasant one.

His chief research interests have been in the fields of fisheries biology, ichthyology and biological oceanography. He has published forty odd papers on whitefish, smelts, herrings, sardines, anchovies, and sharks with a couple of studies on diatoms and albatrosses thrown in. More recently he has been interested in oysters and oyster drills.

He is married and has three children, one boy and two girls. In college he played end on the football team and also did some skiing and mountaineering. Since the war, however, he has found himself too busy with professional duties to find time for any hobbies. Perhaps, as with many marine scientists, it is true to say that his work is his hobby.

HILARY B. MOORE

Dr. Moore was born in Westmoreland, England, in 1907. He attended school in London and took his degree at University College, London. He had always been interested in marine biology and trained specially in fisheries when at college. However, his subsequent work took him into other marine fields. This included studies of marine sediments at Millport Marine Station, the ecology of intertidal animals at Port Erin and at the Plymouth Laboratory, and plankton studies at Bermuda. After a wartime interlude of scientific work for the Imperial Censorship, he went to the Oceanographic Institution at Woods Hole to study the deep scattering layer and then in 1949 to The Marine Laboratory of the University of Miami, where he is assistant director and professor of marine biology, teaching graduate classes in both plankton and marine ecology. He has recently finished writing a textbook of marine ecology—the first of its kind. This is now in the hands of the publisher and should be in print before long. Dr. Moore, for hobbies, designs and makes instruments and gadgets and also restores old furniture.

SCIENTISTS AND AUTHORS

In order that the Bulletin may fully reflect the international nature of its membership and of its objectives, the Editor will be glad to consider for publication illustrated articles for the general reader dealing with institutions of marine science or with subjects related to marine research throughout the world.

Looking Ahead

THE BULLETIN is mailed without obligation to those who are interested in the oceans and in the progress of scientific research concerning it.

It is hoped that, with the growing interest and advice of members and others who receive the Bulletin, it will be possible in the future greatly to expand and develop it and eventually to include articles in nontechnical language from all parts of the world, fully illustrated in color. In order to do this, the editors welcome advice and criticism, as well as articles suitable for publication.

Since the Foundation is a nonprofit organization it is necessary to support the cost of publication by extending the active membership. It is hoped that those who are interested in the objectives of the Foundation and who enjoy the Bulletin will give their support to this by bringing it to the attention of their friends and by becoming members themselves.

According to a ruling of the U. S. Treasury Department donations made to the Foundation are deductible in computing taxable income as provided for by the 1954 code.

ACKNOWLEDGMENTS

THE FRONT COVER photograph of breaking wave and illustrations on pages 54, 56, 57, 59 by Charles E. Lane.

The Back Cover is a Miami Herald photograph of *Criollo* hidden by seas, as she rounds U. S. C. G. cutter *Aurora,* windward mark in the Lipton Cup race this year.

Inside Front Cover and page 44, Bernard L. Gordon.

Pages 2, 4, 5, 6, 7, 17, 32, 33, 35, 36, 37, 40, 49, 50, The Marine Laboratory, University of Miami; pages 9, 26, Howard Thuet, Lou Marron — University of Miami Expedition; pages 10, 11, William Saltmarsh; Page 12, Public Relations Office, Fiji; Pages 19, 20, 21, 22, 23, 24, Chr. Salvesen and Co., Leith; Page 28 from The Ocean River, by permission of Chas. Scribner's Sons; Page 30, The Woods Hole Oceanographic Institute; Page 39, Fred Mizer; Page 43, Florida Photo Co.; Page 53, D. H. Mills.

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Offices: The Marine Laboratory, University of Miami,
439 Anastasia Avenue, Coral Gables 34, Florida